ENGINEERING NEWS

SOMEWHAT later advices from the Nicaraguan Survey Expedition than are conveyed in our correspondent's letter, elsewhere published, give the following items of interest:—J. FRANCIS LE BARON, together with Dr. SELINAS, is making a reconnoisance of the San Carlos river. Mr. PEARY is (Jan. 4) at the mouth of the San Carlos. In regard to the relations of the proposed canal and the disputed boundary question between Nicaragua and Costa Rica, we have the following: The territory in dispute extends up the right bank of the San Juan from Greytown nearly to Castillo, 85 miles. This trouble dates back to 1858, when a treaty was duly drawn up and ratified by the Congress of each country; but not by two successive Congresses as required by law to make it valid. The dispute is now submitted to the President of the United States for settlement, but in no way affects the concessions of the Canal Company so far as building the canal is concerned; either nation will grant the right of way; hence it is only a question of which country will profit from the canal. On the most popular route one bank of the canal will be the boundary of Costa Rica for 24 miles along the San Juan river, and this bank is all that the latter country will own in any event. In the three weeks that the party have been on the ground it has rained nearly every day. The rainfall is very heavy; on Dec. 29, 6¼ in. of rain fell in 24 hours, and on the following day 4 in. fell, as registered by the gauges at headquarters. The San Francisco river rose about 8 ft. in a few days; and the San Juan, 5 ft. in the same period. The ground being surveyed is bad, is generally swampy with very thick undergrowth. The insects are very annoying; musquitoes swarm, together with an infinite variety of bugs of almost every conceivable size, color and shape.

GEN. NEWTON, the New York Commissioner of Public Works is quite right in his opinion that the gas rates in this city of $1.25 per thousand feet are much too high. He states that in many streets there are four or more sets of mains owned by different companies. The supposition was that the competition between the different companies would bring down prices to the lowest limit. But gas companies are are not going to always cut each other's throats when harmony and an agreement concerning rates will enable them to charge such rates as they please. It is because the rates are now fixed by law, not because of competition, that the rates are no higher at present. Someone, however, has to pay for all the unnecessary mains which have been laid, and under present rates it is the consumer who is doing this. Nevertheless, the duplication of mains is still going on and the damage to city pavements in laying and repairing mains is enhanced by so much over the necessary amount. The total amount of gas mains in New York City on Dec. 31, last, was 1,118⅜ miles, of which 101 miles were laid in 1887.

A bill to bridge the Mississippi river at Memphis, was passed in the House of Representatives on Jan. 24. The bridge will be built by the Kansas City, Fort Scott & Memphis Railway. The bill provides that the two middle or channel spans shall not be less than 600 ft. in the clear, and no span is to be less than 450 ft. in length. The headway at all points to be 65 ft. at extreme high-water, and the bridge must be at right angles to, and the piers parallel with the current of the river. All railroads are to have an equal right to use the bridge with equal privileges, upon payment of a reasonable compensation for such use to the constructors, or owners.

ON the same day as the above, another bill was passed in the House, for a bridge across the Missouri, at Lexington, to be built by the Lexington Bridge Co. It is to be a railway bridge, with not less than 350 ft. spans; to have a clear headway of 50 ft. above extreme high-water. But it may be built with 200 ft. clear draw openings.

SOME one has discovered that the month of February, 1866, was the most remarkable in the world's history in that it had no full moon, there having been two each in January and March. This, it is creditably asserted, has not occured before since the alleged date of tho creation of the world, nor for a very considerable space of time before (a million or two years) if the world then existed, nor will it again occur for the very suspiciously even period of 2,500,000 years. The peculiarities of February, 1866 are ancient history in one sense, but as this allegation was news to us we put it in its appropriate place as such.

A train in Augusta, Me., Jan. 21, was split at a switch, the engine misplacing it and going one way, after breaking the switch rod, and the train going the other way, the tender being "no whar". No harm was done except to the tender, but that was badly wrecked, and the escape from much worse results was a narrow one, due to the fact that the speed was slow. It hardly seems possible for any amount of care to eliminate entirely this form of danger from facing point switches. The danger is much greater with the old style of stub switches than with a good form of split switch, but the same thing happened to an interlocked switch at Spuyten Duyvil a year ago, as our readers may remember.

DURING the week railroad traffic has been considerably interfered with by heavy snow storms. In New York State, New England and the Northwest, railroads have been snowed under, on many lines to such an extent as to entirely blockade the track, trains being abandoned for several days in some cases. Comparatively few accidents are reported due to the storms and the disorganization of the traffic, but much inconvenience has been caused by the delay of the mails, and when the storm abated and the snow could be removed without blowing back again into the cuts, superintendents had a busy time in straightening out the freight traffic.

THE most serious railroad accident of the week occurred on the Lake Shore & Michigan Southern Railroad, Jan. 30, a freight train going through a trestle 2 miles west of Pine, Ind. Among the cars was a naphtha tank which broke and the wreck was almost entirely consumed. One man was killed.—A rear collision between two sections of a passenger train on the Savannah, Florida & Western Railroad, Jan. 28, resulted in the death of 3 men and the burning of several cars. In 3 other accidents the cars caught fire.

A broken flange on a wheel of an Old Colony Railroad train derailed a car near Tremont, Mass., on Feb. 1, but as the train was slowing down, a serious accident was averted.—A broken flange on the driving wheel of a Chicago, St. Paul & Kansas City Railroad train, ditched both engines and derailed a car at Luray, Ia., Jan. 26. One man was injured.

THE Boston & Maine Railroad issued orders after the Bradford disaster that all wheels on through trains be hereafter tested at Salem. The order went into effect Wednesday last, and a prompt result was the detection of a cracked wheel on the smoker of the "Flying Yankee", which would otherwise have run through to Boston. It does not follow that it would have done harm, but the order was certainly justified by the results.

During 1887 there were on the New Croton Aqueduct, 64 serious accidents to workmen, 27 of which resulted in death and 37 in serious injury. From the beginning of the work to Jan. 1, 1888, 86 men have been killed and 144 seriously injured, making a total to date of 230 serious accidents.

The statistics show a noteworthy disproportion in the number of accidents happening under the various contractors. Brown, Howard & Co. have the contracts for the upper 13 miles of the aqueduct. O'Brien & Clark and Heman Clark come next with the remaining 16 miles. John Brunton & Co. have the contract for the gatehouse at 134th St., and Smith & Brown that for the Croton gatehouse. Since the beginning of the work, on Brown, Howard & Co.'s work there were 49 killed and 79 wounded, a total of 128. On O'Brien & Clark's and Heman Clark's work there were 33 killed, 55 injured, a total of 88. On John Brunton & Co.'s work there were 2 killed and 6 wounded, a total of 8, and on Smith & Brown's work there were 2 killed and 4 wounded, a total of 6.

A synopsis of the fatalities during 1887 on Brown, Howard & Co.'s work shows that 6 were killed by rock and bricks falling on them, 5 were killed by falling down shafts with cars, and 2 by the cars falling upon them; 3 by the explosion of dynamite in an old drill hole, and 1 by the premature discharge of a blast by lightning; 2 were burned to death, 1 was crushed by a descending cage, 1 knocked his brains out against a projecting timber while pushing a car.

A National Geographic Society has been incorporated at Washington, D. C. for the increase and diffusion of geographic knowledge. The organization was completed at a meeting held January 27th, when the following officers were elected for the ensuing year:

President, GARDINER G. HUBBARD.

Vice Presidents each representing a department of geographic science:

Geog. of Land, H. G. OGDEN, U. S. Coast Survey.
" " Sea, General A. W. GREELEY, Signal Office.
" " Air, Com. J. R. BARTLETT, Hydrographic Office
" " Life, Dr. C. H. MERRIAM, Ornithologist Agr. Dept.

Geographic Art, Prof. A. H. THOMPSON, Chief Geographer Geolog. Survey.

Treasurer, CHARLES J. BELL.

Recording Sec'y., HENRY GANNETT, Geolog. Survey.

Corresponding Sec'y. GEO. A. KENNAN.

Managers, J. C. WELLING, Pres. Columbian Univ; W. B. POWELL, Supt. Schools; Capt. ROGERS BIRME; HENRY MITCHELL, Coast & Geodetic Survey; MARCUS BAKER, Geolog. Survey; G. BROWN GOODE, Nat. Museum; W. D. JOHNSON, Geolog. Survey; CLEVELAND ABBE, Signal Office.

The Society has an enrollment of nearly 150 members.

ACCORDING to the report of Secretary JOHN C. SHEEHAN, the New Croton Aqueduct Commission has issued bonds to the amount of $16,383,537 for expenses connected with the aqueduct work. Of this amount $14,745,604 has been expended. Last year $7,242,293 was paid out; $227,513 of this being for property acquired.

CHIEF Engineer BIRDSALL reports that last week 11,000,000 galls. of Croton water were used in this city in excess of the supply from the old aqueduct. This means a heavy draft on storage and is charged mainly to waste from the attempt to prevent freezing in badly located and exposed pipes by letting the taps run.

MUCH opposition is being developed to the bill now before Congress obliging every railway conductor to have a U. S. Government license. The bill was originated by officers of the United Order of Railway Conductors which has a membership of about 8,000, the whole number of conductors in the United States being about 40,000. As the principal faults and failings which a conductor is liable to work more to the injury of his employers than to the public, it is difficult to see why railroad corporations should not be trusted to look after their own interests without help from the Government.

THE Buffalo grade crossing agitation seems to be taking the form of a project for a great Union station. Chief Engineer BUCKHOLZ, of the Erie, has submitted such plans; the Erie evidently being quite ready to make a shrewd use of the existing agitation to improve its own terminal facilities, as compared with the Central's, which have put it at a great disadvantage. The plan has many excellent features, but is accompanied by certain very objectionable ones as respects the street crossings (carrying them over the tracks) which the city, if it were wise, would never assent to. Usually, however, a city can be relied on not to be wise in such matters—in time to be of any use.

THE MELBOURNE EXHIBITION.—AN international exhibition is to be held this year at Melbourne, Australia, and as there in a large field for American manufacturers in the Australian colonies it is hoped that manufacturers will take advantage of this opportunity for extending our foreign trade. J. T. SHEEHAN is the agent in this country, and may be seen at the office of E. & H. Batcheller & Co., 106 Summer street, Boston, Mass.

High Masonry Dams.

The following is the report of A. FTELEY, Consulting Engineer, to B. S. CHURCH, Chief Engineer, New Croton Aqueduct, New York. The report of Mr. CHURCH was printed in our issue of Jan. 14, 1888:

The following is a brief synopsis of the research on the question of high masonry dams, which you requested me to make for the ultimate purpose of determining the forms, dimensions, materials and mode of construction of the proposed Quaker Bridge dam.

It is of such importance for the welfare of the future water supply of New York that this subject should be exhaustively studied, and the amount of money involved is so large, that the necessity of acquiring a full knowledge of the practice followed by other engineers in similar instances, became at once evident; their methods were carefully considered and weighed, and the best practice was followed, as much as practicable. Owing, however, to the unprecedented magnitude of the proposed dam, which gives rise to some important problems heretofore unsolved, it became necessary, in some instances, to leave the beaten path and to resort to a basis of operations different from that established by others.

It should be said here that the subject, when submitted to us, was not entirely new, and that we had the advantage of having before us the result of the joint-work of Messrs. ISAAC NEWTON, Chief Engineer, and E. S. CHESBROUGH, and J. W. ADAMS, Consulting Engineer of the Department of Public Works, formulated in the official plan of Quaker Bridge dam, submitted by the Department of Public Works to the Aqueduct Commissioners.

It is not within the scope of this report to consider the advisability of the construction of Quaker Bridge dam as an essential part of the new system of water supply for New York; The opinion of high engineering authorities should place beyond a reasonable doubt the necessity and feasibility of the structure, but additional confidence in its ultimate success must be obviously increased by a consideration of the high masonry dams now in successful operation, although of less magnitude. The most important ones have been represented in section and in plan on sheets Nos. 1 and 2,[1] which accompany this report. Table I. gives statistical data in regard to the greatest number of them, and does not require any explanation; in many cases, data which appeared of interest for the purpose of comparison, were obtained by calculation from plans and other sources of information at hand, but they are in every case designated by proper references.

A glance at sheet No. 1 shows a variety in the shape of the transverse sections of the various dams. The older Spanish dams, Puentes, Alicante, Val del Inferno, etc., are conspicuous by their heavy sections; it is plain that their constructors did not design them in accordance with the best principles, and that they have, by accumulating masonry, uselessly increased the pressures on the lower part of the dams. From these increased pressures, however, which in the Almanza dam attain 14 tons per sq. ft. we may derive the proof that the low limits of pressures, recommended by the more modern authorities, can be safely exceeded, as the old Spanish dams (with the exception of the Puentes which failed from a different cause) have been in long and successful operation.

The modern French type is represented on sheet No. 1 by the following dams: Furens, Villar, Ban, Habra, Komotau, Ternay, Hamiz, Gran Cheurfas, etc: it is almost needless to add that this form, first indicated by Mr. SAZILLY, is due to a better understanding of the magnitude and direction of the forces acting on a dam at various stages of the water in the adjacent basin, and that it is from the construction of these dams, and from the indications of their designers, that the most useful information can be procured. Other modern dams, the Gileppe, the Vyrnwy, the Zola, present special features which shall be considered in time.

Before entering into the consideration of these various structures, however, it is proper, in order to comply with the request of the Aqueduct Commissioners, that I should refer, as succinctly as possible, to the authorities which have been consulted on the subject, and to the views advanced by them. We know little or nothing of the methods used by the engineers who built the old Spanish dams to determine their proportions. The design of the more modern dams, built later in France, for the water supply of canals, "show (says Mr. KRANTZ) a clearer conception of the forces to be overcome, and greater care in regard to economy. In a word they show a real advance in the art of building. Still they are not irreproachable. It is obvious that they cannot be taken for models."

Mr. SAZILLY was the first[2] to consider the subject in all its bearings. "With rare insight, he was able to discern the nature, amount, and direction of the various forces which act on the reservoir walls at the different periods of filling the basins. From them he deduces rational forms to be given to constructions of this sort."[3]

His deductions led him to a profile of a stepped section, which he advocates for several theoretical and constructive reasons; he recommends a limit of pressure on masonry of about 6 tons per sq. ft., and shows his profiles to a height of 160 ft. His method of calculation is intricate and requires, as usual in such cases, a series of approximations; he assumes that the pressures are distributed in accordance with formula (1 and 2), which seems to have been universally adopted to express the distribution of pressures on any horizontal joint of a dam, and which will be mentioned again in the course of these remarks.

Mr. DELOCRE[4] developed a very complicated method for determining the profile of high masonry dams, which he applied to the design of Furens dam, admits a limit of pressure of about 6 tons per sq. ft., and does not confine the point of application of the resultants to the middle third of the joint; he assumes in his calculations for the masonry a weight of 125 lbs. per cu. ft. Mr. GRAEFF,[5] who had charge of the construction of the Furens dam, must be mentioned as the author of a description of that structure. Mr. KRANTZ[6] gives an interesting and comprehensive review of the subject of high masonry dams, and suggests a full series of profiles for dams of various heights, on which the ultimate pressures are about 6.1 tons per sq. ft. He does not develop the methods which led him to the determination of his profiles. His exposition of the comparative sections of high masonry dams is very complete. Prof. RANKINE,[7] taking occasion of his being called upon to report on the construction of a proposed dam in India, gives his views on the subject of high masonry dams. He calls attention for the first time to the necessity of using a lower limit of pressure on the front than on the back face, for the reason that the pressure upon a curved face of masonry, at any point, is tangent to the curve at that point. He also argues on the advisability of keeping the resultants within the middle third of any joint, in order to avoid tension, which, he claims, would otherwise exist at some points of the faces. Finding also that, for dams not exceeding 150 ft. in height, logarithmic curves give a close appoximation to a correct profile of the faces and furnish a rapid method for determining the outline of a dam section; he recommends their use.

Mr. BOUVIER,[8] in an article, on the Ternay dam, claims that formula (1 and 2), used to compute the distribution of pressure on the base of dams, should be modified as to make the resulting pressure depend upon the oblique resultant, in the case of a full reservoir, thus increasing the pressures as otherwise calculated. This method accomplishes the suggestion of Prof. RANKINE to adopt a lower limit of pressure for the front face. Mr. BOUVIER departs from the practice of his predecessors, and admits, on the strength of the crushing resistance of rubble masonry and of hydraulic lime mortar, as shown by Mr. VICAT, that the pressures on masonry can be safely increased to 14 1-3 tons per sq. ft.

Mr. POCHET[9] gives a description of the Habra dam in Algeria, refers to the poor quality of the materials used and, after giving a list of pressures which obtain in various cases, adds that the limit of pressure of 6 tons per sq. ft., generally admitted by engineers, must not be taken as absolute, and that, in his belief, experience will lead to a much bolder practice within the limits of safety.

Mr. PELLETREAU,[10] after a purely theoretical discussion upon the designing of high masonry dams, submits a mathematical method no simpler than that advanced by Mr. DELOCRE.

Mr. de BEAUVE[11] has devised a graphic method for determining the profile of high dams; his method considers only the limiting condition of pressure, and it requires considerable modification to introduce the condition of confining the point of application of the resultants to the middle third of the base. The determination of a profile by this method is very laborious, but exact.

Mr. GUILLEMAIN, Professor of the School of *Ponts et Chaussées*, Paris, in an unpublished lecture delivered at that school, reviews the whole subject of designing high masonry dams; he considers that the points of application of the resultants should be confined within the center third of the base, and he takes the same views of the computation of pressures distributed on the base of a dam, as formulated by Mr. BOUVIER, and suggested by Prof. RANKINE.

Mr. McMASTER[12] gives some mathematical equations for the determination of a profile; he also devotes considerable space to certain practical considerations in regard to the building of masonry dams.

Mr. AYMARD,[13] having access to the early public records concerning the older Spanish dams, has made use of that information, in connection with his examination of the structures, to give a complete account of them; interesting facts connected with the construction and use of the dams are found in the work.

Mr. CRUGNOLA,[14] in his exhaustive treaties on retaining walls, devotes a considerable space to masonry dams; he shows the sections of a number of dams, and gives a graphic method for determining the lines of resistance in any assumed profile. The author recommends typical sections for various heights up to 164 ft.

The following documents, bearing on the subject have also been consulted, viz:

The manuscript report of Mr. BIDEAU to the Minister of Public Works of Belgium, on the plan of the Gileppe dam. A memoir on the same structure by Messrs. DETIENNE and LECLERK. Miscellaneous notes on the same dam (Proc. Inst. C. E., ENGINEERING NEWS, etc.) An article on high masonry dams by Major TULLOCH (Professional Papers on Indian Engineering). Proc. Inst. C. E. Vol. 56, p. 101, on the description of a dam built of concrete in Australia for the Geelong Water Supply. Proc. Inst. C. E. Vol. 71, p. 379, giving a short description of the Villar dam. *Scientific American*, May 28, 1887. A historical and descriptive review of earth and masonry dams, with plans, by DAVID GRAVELL. A report by Mr. GEO. F. DEACON, C. E., as to the Vyrnwy dam for the water supply of Liverpool, with full account of the methods used for the determination of the profile and for the construction. A paper by W. B. COVENTRY, Proc. Inst., C. E., Vol. 85, Paper No. 2110. *Annales des Ponts et Chaussées*, June, 1872. A detailed and illustrated description by Mr. PAMAIRESSE, of the Barrage de Cheliff. *Annales des Ponts et Chaussées*, Vol. XI., 1886. A theoretical discussion by Mr. HETIER upon the designing of the profile of masonry dams. *Giornale del Genio Civile*, 1885; also, *Bacini di alimentazione per cura di* G. TORRICELLI, C. E. *Annales des Ponts et Chaussées*, June, 1872. A detailed description of the Masonry dam on the "*Canal du Verdon*," in France, by Mr. de TOURNADRE, with note describing the Barrage of Zola, 124 ft. high. TORRICELLI.—*Relazione presentate al Ministero di Agricoltura* LAGRENÉ.—*Cours de Navigation*—II. *Die Thalsperre der Gileppe bei Verviers* (F. KUHN, Dresden). *Der Civilingenieur* for 1879.

In addition to these special references, it is obvious that other classical and well known authorities have been consulted.

When considering the exceptional magnitude of the proposed Quaker Bridge dam, it becomes at once apparent that it is necessary to depart in its design, to a considerable extent, from the practice hitherto followed. The accumulation of ponderous solid masonry with the great and ill defined strains to which it must be submitted is at best, although the only advisable one under the circumstances, a rude and expensive way of solving the problem, and some attempt was made to see whether, in this case, a structural building could not be erected, with its various parts so designed as to resist well known strains, and to render it comparatively easy to locate and remedy defects, if any were found, after construction.

This study led to the form of an inclined plane, built of masonry of sufficient quality and thickness to resist the percolation of water, and supported on groin arches and stone pillars; the junction of the structure with the sides and bottom being effected by means of heavy masonry walls penetrating the rock to suitable depths.

Whatever may be the objections to such a structure, it may be seen that all its parts would be subject to well known strains, and would be left open to inspection; this research, however, was not extended beyond its preliminary stages, because it soon became evident that the masonry pillars and other parts supporting the structure, should be made of such cut stone masonry as could support the heavy weight reposing on them, and that the total cost of the dam would be unreasonably high. An iron structure built on the same principle would be feasible and economical, but would not present such guarantees of permanence as must obtain for a dam which is to be the main reliance of the future water supply of New York.

An earth dam, with a core of masonry, was also considered. In such structures, the thrusts exerted by the earth against the center wall, during construction and at the different stages of the water surface, when filling or emptying the adjacent basin, are unknown or, at the best, very uncertain; if the wall became fractured under their action, or allowed the water, in places, to pass through, the leaks, under such a considerable and unusual pressure, would endanger the stability of the earth embankment. Moreover, the authorities agree that this kind of structure is not safe to adopt beyond a certain limit of height, and it was thought unwise to attempt an experiment which, owing to the importance of the interests involved, was not justified by the saving in expense which might have been effected by its adoption.

In this case, where the welfare of New York is con-

[1] Published in ENG. NEWS of Jan. 7 1888.
[2] Annales des Ponts et Chaussées, 1853.
[3] Krantz, p. 21.
[4] Annales des Pontes et Chaussées, Oct., 1866.
[5] Annales des Ponts et Chaussées, Sept. 1866.
[6] Study of Reservoir Walls, by J. B. Krantz, translated by F. A. Mahan, 1885.
[7] Miscellaneous Scientific Papers, 1881.
[8] Annales des Ponts et Chaussées, Aug. 1875.
[9] Annales des Ponts et Chaussées, April 1875.
[10] Annals des Ponts et Chaussées, Oct. '76, Aug. '77, Mar. '79.
[11] Manuel de l'Ingenieur des Ponts et Chaussées, translated by E. Sherman Gould, C. E., 1881.
[12] "High Masonry Dams"; Van Nostrand's Science Series, No. 22.
[13] Irrigation du Midi de l'Espagne.
[14] Muri di Sostegno. G. Crugnola.

cerned, and where the consequences of a possible disaster with 30,000,000,000 galls. of water behind the dam, may well be imagined, we must deal with certainties; we have before us many successful instances of masonry dams, although of less magnitude, and the proposed structure can be so proportioned and constructed in masonry as to stand effectually the great pressure to which it is to be subjected.

After this preliminary consideration of the subject, it was consequently decided, in conformity with the opinion expressed by the Engineers of the Department of Public Works, to build the dam of solid masonry with such differences from previous engineering practice as would be necessitated by the special features of the undertaking.

In designing the profile of the dam, three well known main conditions are to be observed.

1st. The point of application of the resultant of the forces, acting on the dam, whether or not it be under water pressure, must not be beyond the center third of the base.

2d. The pressures on the masonry at either face, and at any point, must not exceed a certain safe limit.

3d. The sections of the dam, at any point, must be such that no sliding can take place.

The means used by the various authorities, analytically or graphically, for the determination of profiles fulfilling wholly or partly these conditions are somewhat different, but the greater number having based the computation of the distribution of strains on the lower joint of the dam or on any horizontal joint, on the method reproduced by Mr. De BEUAVE [15] in his "*Manuel de l' Ingénieur*," it is proper that attention should be called to it.

The pressure at each end of the base or joint "is given by one or the other of the two formulæ

$$(1)\quad p = 2\left(2 - \frac{3u}{l}\right)\frac{W}{l}$$

$$(2)\quad p = \frac{2}{3}\,\frac{W}{u}$$

according as u is greater or less than $\frac{l}{3}$."

l = length of base or joint.

p = pressure per unit of surface at one end of base or joint.

u = distance from the point of application of the resultant to same end of base or joint.

W = total pressure on base or joint.

This method is based on the hypothesis that the masonry forming the dam is absolutely rigid and leads to the conclusion that the maximum pressures, on any base, take place at one end of it when the reservoir is full and at the other end when the reservoirs empty. But the structure is not rigid, and there is obviously some uncertainty in regard to the distribution of the strains through the mass of masonry. This view of the subject is illustrated in the following extract of a report of Mr. J. B. FRANCIS to the Chief Engineer of the Department of Public Works: "The main part of the dam, I am informed, is intended to be of rubble masonry laid in Portland cement. Although the work may be done in the best manner possible, it will yield a little to the pressure, and the amount of the compression in different parts of the dam will be unequal and nearly proportional to the pressure and depth of the mass of masonry at its different parts. The amount of the compression at different points may be too small to be observed, but I am of the opinion that it will be sufficient to modify to a material extent the result of calculations based on the hypothesis of an incompressible mass, and the effect, I think, must be to cause a distribution of pressure very different from that indicated by the calculations, and to relieve to a great extent, if not entirely, the outer toe of a high dam designed strictly according to the DEBEAUVE method from the pressure due to the weight of the high part, combined with the horizontal pressure of the water against the up-stream face of the dam. The entire weight must of course be supported on the base, but I think a much larger proportion of it will be upon its central parts, than is indicated by the calculation, and that the pressure at the toe, instead of being a maximum, will be a minimum."

As an additional illustration of the uncertainty of the distribution of pressures on the base of dams, the following extract from RANKINE'S "Miscellaneous Scientific Papers," may be of interest: "The assumption on which this rule is based, of an uniform rate of variation of that component of the pressure which is normal to the pressed surface, is known to be sensibly correct in the case of beams, and is probably very near the truth in walls of uniform, or nearly uniform, thickness. Whether, or to what extent, it deviates from exactness in walls of various thicknesses is uncertain in the present state of our experimental knowledge."

Whatever may be the distribution of the pressure on the base of the dam, it must be admitted that the strains are distributed otherwise than indicated by the formulæ; but as we have no other means of determining these strains with accuracy, and as, on the other hand, the formulæ indicate resulting pressures larger than they are in reality, the profiles based on that method show an excess of strength which gives a further guarantee of safety.

The distribution of strains on the base and horizontal joints of the dam has consequently been computed, in the numerous cases considered, by formula (1), with the understanding that it indicates, at the ends of the joints, pressures evidently higher than the actual ones, thus adding to the computation a factor of safety of important, although uncertain, value.

The sections of dams built or proposed by various authorities have been determined by methods involving the consideration of the horizontal and vertical forces acting on the dam, and of the magnitude, direction, and application of their resultant force. Those methods, with the exception of some analytical ones mentioned before, and which are too complicated for practical use, proceed by successive approximations of the profiles, and require considerable time. As it was desirable, in this research, to go thoroughly over the ground and review a number of different profiles before coming to final conclusions, a more expeditious method was sought and used for a large portion of the preliminary studies. This method, although proceeding by successive approximations, was found of great service for simplifying the computations. It is based upon the principle of moments.

For convenience and accuracy, the profile is divided into horizontal layers of a given thickness. The calculation is begun at the top of the dam, each layer being figured separately. A layer being given, and the profile of the dam above it being known, certain dimensions are assumed for the lower joint of the given layer; and the position of the two resultants (in case the reservoir is full or empty) are determined by taking moments about assumed axes. If the first profile does not give results in accordance with the assumed limiting conditions, another is attempted, and a third attempt is very rarely needed.

To simplify the computations the weight of the cubic foot of masonry is taken as the unit of weight throughout the calculations; consequently, when considering a vertical section of the dam 1 ft. thick, the area of the section in square feet will give the weight in cubic feet of masonry; hence laborious reductions are avoided.

A practical example of the method will illustrate it.

The upper part of a dam m, n, a, b, Fig. 5, (see Inset,) being already known, it is desired to determine an additional section 20 ft. high. The depth of water above the base of the new part is 150 ft.

The weight of masonry is assumed at 156.25 lbs. per cu. ft. (This weight is within less than a pound that of a block of masonry built for experimental purposes with stone quarried in the neighborhood of Quaker Bridge dam, and has the advantage of being a single multiple (2.5) of the weight of a cubic foot of water). The limiting pressure for the back face is supposed to be 20,625 lbs. per sq. ft. (10 kilos per square centimetre) = 132 units, expressed in cubic feet of masonry; the limiting pressure on the front face being 105 cu. ft. of masonry.

We want to find first the point of application of the resultant when the reservoir is empty. The resultant W for the part above joint $a\,b$ is known in magnitude and position = 5,689.5 cu. ft. masonry. The axis of moments is 192.5 ft. from point b.

From the previous form of the profile let us assume that on the front face we will add $d\,k = 21$ ft. to the base a, b, and on the back face c, l, = 4 ft.

Divide the trapezoid a, b, c, d, into one rectangle a, k, b, l, and two triangles b, c, l and a, d, k.

Taking the moments about the assumed axis

	Weights in cubic feet of masonry.	Lever Arms.	Moments.
Resultant W.....	5,689.5	224·1	1,275,388
Rectangle 93×20..	1,860	239·	444,540
Triangle 21×10....	210	292·5	61,425
Triangle 4×10.....	40	191·2	7,648
Totals.....	7,799.5		1,789,001

$\frac{1,789.001}{7,799.5}$ = distance of the resultant from the axis of moments = 229.4 ft.

Distance of the point of application of the resistance from point c = 229.4 — (192.5 — 4) = 40.9 ft.

In the case when the reservoir is full, the pressure of water will throw the resultant toward the front edge.

Calling h the depth of water above $c\,d$, the moment of the water pressure around point d, $= \frac{h^3}{2} \times \frac{h}{3} \times \frac{1}{2.5} =$ 225,000, $\frac{1}{2.5}$ being the ratio of the weight of water to weight of masonry.

Then taking moments about the resultant found in the first case, $\frac{225,000}{7,799.5}$ = 28.9, which is the distance between the points of application of the two resultants.

Applying now formula (1) it will be found that the pressures at d and c are 101.6 and 126.7cu. ft. of masonry, respectively, inside of the assumed limits of pressure If greater accuracy is needed, a new trial may be had with slightly lower values for d, k and l, c. The results thus obtained have been frequently checked by graphic methods.

In the various computations of profiles which will be here mentioned, the vertical pressure of water on the back face of the dam is omitted; its omission has only a slight influence on the results, which it affects on the side of safety, and simplifies the calculations.

It may be noticed that in the course of these remarks, the height of Quaker Bridge dam has always been computed, from the bed rock, many feet below the river bed, to the top of the structure. It is obvious that the position of its lower part in a deep bed of gravel, and the counter-pressure due to the earth and to the water on the front face, modify to a certain extent the conditions of stability and the intensity of the strains, but no additional strength is given to the dam by the fact of its being imbedded in a great depth of earth, and with due regard to the modifications which may be introduced on account of the presence of a counter-pressure, the dam must be treated as one structure of a uniform character throughout its whole extent.

At the beginning of this research, a trial profile, attempted under conditions of assumed pressures within the limits used by the best authorities, showed conclusively that the height of Quaker Bridge dam would compel us to depart from the practice of others, as, in order to remain within the prescribed limits, it would be necessary to spread the lower parts in an impracticable manner, and to incline the slopes to an extent incompatible with strength. Fig. 1, illustrates this fact.

The same result would follow the use of the RANKINE method and of the types advocated by Messrs. KRANTZ, CRUGNOLA and others (see Fig. 7).

It was then thought that it might be advisable to change the quality of the masonry at the points a, b, Fig. 2, where the application of the pressures recommended became impracticable, and to adopt beyond these points a cut stone masonry capable of supporting greater strains. Further consideration of the case, however, developed the fact that this modification would be very costly owing to the size of the dam; it is also preferable not to destroy, if possible, the homogeneity of the mass of masonry.

The only alternative left was to assume higher limits of pressure. Is it safe to do so? In answer to that question, we may refer again to the opinion of Messrs. BOUVIER and POCHET who admit that bolder practice can be resorted to within safety. It must be said also that, in fixing their low limits of pressure, the French engineers have kept in view the fact that the dams may be put under full pressure when their comparatively slow setting mortars have not gained their full strength, while in our case the cements used, with the possible exception of the uppermost part of the dam, will have time to harden satisfactorily before the whole force of the water pressure is brought to act on the masonry. Moreover, it is well known that there are in existence many structures, the foundations of which have to support weights superior to any that may be sustained by the lower parts of Quaker Bridge dam.

A computation made of the maximum pressure at the outer toe of some existing dams, shows that they attain in several cases from 11 to 14 tons per sq. ft.

It is well known that the ultimate crushing strength of the materials to be used in Quaker Bridge dam is much above the pressure which will obtain in that structure, and it must not be forgotten that the limits of strength deduced from experiments are obtained with samples of a small bulk, presenting much less resistance to crushing than large masses of masonry laterally supported.

Adding to these considerations the fact already mentioned, that the pressure on the faces of the dam are undoubtedly below the figures calculated by the general method followed by us, it may be asserted that the pressures calculated for the lower part of the proposed structure can be safely adopted.

The question may then be fairly asked whether these high limits of pressure, inasmuch as they are considered safe, should not be adopted for the upper part of the profile of the dam, as well as for the lower part. They could, in our opinion, be adopted, but an insignificant saving only, would thus be effected and some objectionable features would be produced. The upper part of the dam, which has to resist the additional strains due to the shock of waves and ice and to the action of frost, possibly at at a time when the mortar is not fully set; and which has to carry a roadway, must be designed much wider than it would be if it was subjected only to the combined pressure of masonry and of quiescent water; such being the case, the thicknesses of masonry corresponding to the higher pres-

[15] "Manuel de l' Ingenieur des Ponts et Chaussées. Translated by E. Sherman Gould, C. E., 1881.

TABLE II.

SYNOPSIS OF DATA—THEORETICAL PROFILE—QUAKER BRIDGE DAM.

1	2	3	4	5	6	7	8	9	10	11	12	13
Elevation of Joint Croton Datum	Depth of Water at Joint.	Offset on up-stream face from previous Joint.	Distance from up-stream end of joint to point at which a vertical through the center of gravity intersects the joint.	Distance from down-stream end of joint to point at which the resultant of weight and water pressure intersects the joint	Distance between the points designated in columns 4 and 5.	Total length of joint equ'ls sum of columns 4, 5 and 6.	Total area in sq. ft. equals tot'l weight in cu. ft. above joint.	Horizontal thrust of water above joint	Pressure at up-stream end of joint.	Pres're at down-stream end of joint.	Ratio of horizontal thrust of water to weight of masonry equals column 9 divided by column 8.	Fac'r of saf'ty agai't over-turning.
			(u')	(u)	(c)	(l)	(W)		(p')	(p)		
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Sq. ft. Cu. ft. Masonry.	Cu. ft. Masonry.	lbs. per sq. ft.	lbs. per sq. ft.		
171.3	34.7	0	10.0	6.7	3.3	20	834	341	6,516	13,031	.29	3.00
156	50	0	10.5	8.7	7.0	26.2	1,187	500	11,328	14,156	.42	2.24
136	70	0	12.4	12.5	12.5	37.4	1,823	980	15,234	15,234	.54	2.00
116	90	2.3	17.8	17.8	17.8	53.4	2,731	1,620	15,984	15,984	.59	2.00
96	110	2.0	23.7	25.2	22.3	71.2	3,977	2,420	17,453	16,391	.61	2.13
76	130	3.4	31.7	35.1	26.1	92.9	5,618	3,380	18,462	16,384	.60	2.34
56	150	3.4	40.1	45.3	29.2	114.6	7,698	4,500	19,930	17,078	.57	2.55
35	171	3.6	49.1	56.1	32.2	137.4	10,339	5,848	21,822	18,219	.56	2.74
15	20 191	3.4	58.8	65.9	34.4	159.1	13,304 13,508	7,216	23,641	20,084	.53	2.92
-5	40 211	3.4	69.9	75.4	35.5	180.8	16,703 17,519	8,584	25,466	22,680	.49	3.13
-25	60 231	3.4	81.6	84.8	36.1	202.5	20,536 22,372	9,952	27,313	25,691	.44	3.35
-52	87 258	4.6	97.7	97.7	36.4	231.8	26,399 30,960	11,799	30,000	30,000	.39	3.68

NOTE.—Small figures in Column 2 show depth of water on down-stream side of dam.
Small figures in Column 8 represent weight of masonry (equals area masonry) *exclusive of gravel on slopes.*
Large figures in Column 8 below elev. 35 represent total weight of Masonry plus gravel; but in *area* they represent the area of the masonry plus 0.94 of the area of the gravel.

sure assumed for the base, could not be adopted near the top without distorting the profile; if adopted lower down, their effect would be to cause the lower outer slope of the profile to make with the horizontal a sharper angle. Considerable importance is attached to this point; the downward regular transmission of strains due to superincumbent weight in a pyramidal mass of masonry can be relied on within certain limits only, and it is obvious that it would not take place if the slopes were too much inclined on the horizon: the safe limit of acceptable slope is uncertain, and depends on the character of the materials and of the workmanship which enter into the structure.

It may be added also that it is better, *where practicable*, to follow the practice which has been proved by experience to be successful in dams already built, and to depart from it in the parts only to which it is not applicable, and in which further safety is obtained by the greater extent of the bulk of masonry (with its consequent additional resistance to crushing due to increased lateral support, and its additional strength due to the increased surfaces of cement joints.) The lowest layers of the masonry, at the time that the dam will be put under pressure, will also have the advantage of the harder set of the mortar due to the time necessary for the building operations.

The acceptance of this basis of operation disposes of one of the essential conditions previously mentioned for the proper determination of the profile, *i. e.*, that the point of application of the resultants on the base of the dam must be within the center third of the said base, as, owing to the spreading of the latter to correspond to the assumed limiting pressures, this condition obtains in all cases. Let it be added now that the third condition, *i. e.*, the resistance to sliding, need not require any subsequent attention; in all cases the horizontal water pressure tending to make the dam slide on its joints is much inferior to the weight of the masonry, and, when taking in consideration the adhesive power of the cement mortar and the roughness of the surfaces in contact, it becomes evident that no sliding motion can take place.

The weight of the masonry is an important factor in the establishment of a profile, and it can be seen that the weights (actual or assumed) entering into the calculations of the various authorities vary considerably.

Several weights of the cu. ft. of masonry have been used in this research; 156.25 lbs. has been used for the proposed profile of Quaker Bridge dam, having been determined, as mentioned before, by actual experiment.

The change of weight, however, has much less influence on the profile than might be supposed, as is seen from an inspection of Fig. 3, in which the comparative profiles have been designed under the following conditions:

	Weight of 1 cu. ft. of Masonry.	Limit of Pressure per sq. centimeter.
Profile *a*.	125 lbs.	8 and 10 kilos.
" *b*.	145.8 "	7.6 " 9.8 "
" *c*.	156.25 "	8 " 10 "

The weight of the masonry being for the present an uncertain factor, it was useful to see to what extent the condition of stability would be changed, in case a dam, calculated for a given weight of masonry, were afterwards constructed with materials of a greater or lesser weight. A profile was consequently designed using 156.25 lbs., as the assumed weight of the cu. ft. of masonry, and a subsequent computation of the pressures made on the supposition that the actual weight of the masonry was 125 lbs. The same operation was repeated, 125 lbs. being the calculated weight, and 156.25 lbs. the actual weight.

In the first case the pressures were found as follows for the front face:

Depths from top.	Calculated press. lbs. per sq. ft.	Actual pressures. lbs. per. sq. ft.
feet.		
30	11.981	10.750
50	13.260	13.000
70	14.882	15.750
90	15.678	16.625
110	16.146	16.500
130	16.224	16.125
150	15.850	15.675
171	16.146	15.994
288	38.376	35.400

In the second case, the pressures were found as follows, also for the front face:

Depths from top.	Calculated press. lbs. per sq. ft.	Actual pressures. lbs. per sq. ft.
feet.		
30	8.888	9.984
50	10.625	10.000
70	11.338	11.177
90	12.250	12.383
110	13.875	13.803
130	15.827	15.912
150	16.250	16.068
171	16.500	16.378
288	33.460	35.724

These results, obtained with weights so far apart, show that a small error in the expected weight of the masonry forming the dam would not seriously affect the reliability of the profile.

While on the subject of the weight of the masonry, it is proper to consider whether the fact that a portion of the dam, from the river bed to the bed rock below, is to be submerged in water, is to affect the weight of the structure. It would obviously be so, to a certain extent, if the masonry was porous enough to admit water under ordinary hydrostatic conditions, but the dam, at the lower part, is to be so thick and the masonry is to be of such quality that it can be reasonably supposed that the water penetrating it will be mostly, if not wholly, in a capillary condition, and that the whole dam may be considered, for purpose of calculation, as an impervious monolithic mass rigidly and imperviously connected with the rock bottom, and, consequently, not losing weight by the fact of its being in water. It must be added, however, that even if admitting, as it has been by others, that the water would exert an upward pressure on the dam, thus diminishing its actual weight on the bottom, the result would not be such as to disturb, to any objectionable extent, the conditions of stability otherwise established.

This subject leads naturally to the consideration of the advisability of building drains in the mass of the dam, as recommended by others, in order to relieve it from the pressure of water penetrating the masonry. In accordance with the preceding remarks, and with some authorities, their presence is not thought necessary, and it is obvious that, unless their construction is superintended with the greatest care, they may become injurious by introducing water into the masonry under conditions which would then become unfavorable. At any rate, we know by the experience of existing dams that they have been built and work successfully without drains, and we fail to find any sufficient reason to discard that practice.

In the preceding remarks, the conditions of stability referred to have been considered in connection with the base of the dam or with its horizontal joints only, but the tendency of the parts of the dam to rotate about the foot of diagonal joints assumed at various angles, through the mass of masonry, has also been examined, and in all cases, the moment of the masonry around the lower point of the given diagonal joint has been found more than double of the moment of water pressure around the same point.

The conclusions herein formulated in regard to the pressures that it is thought advisable to allow on the base of the profile, and in regard to the slope of the front face, indicate obviously that, in order to determine the profile of the lower part of Quaker Bridge dam, the approximate length of the base and the maximum pressures at the toes, must be arbitrarily fixed within the limits which have been shown here to be safe.

The result of successive approximations demonstrates that by adopting for maximum calculated pressure at the end of the base 15 tons per sq. ft., (a value which, in view of the opinions previously expressed in

regard to the distribution of the pressures on the base, is considered safe), the length of the base of the theoretical profile will be about 230 ft., a length which allows of a front slope likely favorable to the transmission of the strains acting upon the structure from its various points to its base.

In consequence of these views and of the considerations already developed in regard to the limiting pressures adopted for the upper part of the profile, and in view of the comparatively large proportions of the extreme top, it follows that the calculated pressures at the ends of the successive horizontal joints will show progressive values from the top to the base. The few sloping lines forming the outline of the profile, which were adopted to facilitate construction, follow closely the many sided polygonal figure which would be indicated by the successive calculations of a number of horizontal slices of the section.

TO BE CONTINUED.

The North River Bridge.

With a Discussion of Long Span Bridges.

(*Continued from page 59.*)

6. CONSTRUCTION AND DETAILS OF CABLE ARCHES.

At first thought it would appear impracticable to construct braced arches of wire cables from the difficulty of connecting them with the web members. The chord components of some of the web members will, in special cases, exceed 400 tons. To make a connection on the cable as ordinarily constructed for such stress increments would indeed be impracticable.

Before braced cable arches could be thought of at all, a strong and suitable connection for the web members had to be devised. Furthermore, the great difficulty of making straight wire cables of such unprecedented size is also not to be underrated, inasmuch as even on the East River bridge the then largest wire cables had been the cause of much uncertainty and anxiety in respect to getting the wires all strained alike, and to confine them into a solidly wrapped cylindrical section.

It is not a new objection to wire cables, as usually constructed, and one amply sustained by experience, that the unequal heating of the wires from the sun is the cause of uneven expansion and therefore of internal strains. Before the floor beams were suspended from the wire cables of the East River bridge, it was observed, that on a sunny day the clamp connection would from morning to evening turn about 30°, giving external evidence of internal strains from the unevenly expanding wires in the cables.

Obviously, too, the wire wrapping, no matter how thickly coated and puttied with paint, will not keep out the storm water. It will work into the cables and affect the wires. The rain water of cities is always more or less charged with acids taken up from the city atmosphere, and near the sea it is also charged with salt.

The cable, no matter how solidly made in the beginning will in course of time (it may be many years, but the process is sure nevertheless) become fissured and loose, partly from the above pointed out effects of the sun, partly from the action of the loads, and partly from vibration; acidulated water held by capillary force between the wires, has then a chance to do its insidious work.

The coating of a thin film of zinc is a poor protection to the wire. We know from experience, that if this coating is in the least injured, the wire will rust faster than if it were not galvanized. A galvanic action is set up in the presence of acidulated water, having all the corroding action of a galvanic battery.

It is practically impossible to prevent injury to this coating of zinc during the progress of the work. There is strong ground for belief, that plain ungalvanized wire merely protected by a coating of pure linseed oil is safer than the equally well painted galvanized wire. However, the best way of all to protect the cable is to keep the water out entirely and more certainly, by means of a solid sheet cover or steel envelope about ⅛ ins. thick and this is the plan proposed. To protect the cable against uneven heating an air space of 2 ins. is left between the steel mantle and the wire cable.

The connections and cable sections are shown in the detail engravings, also, a section of the East River bridge cable for comparison.

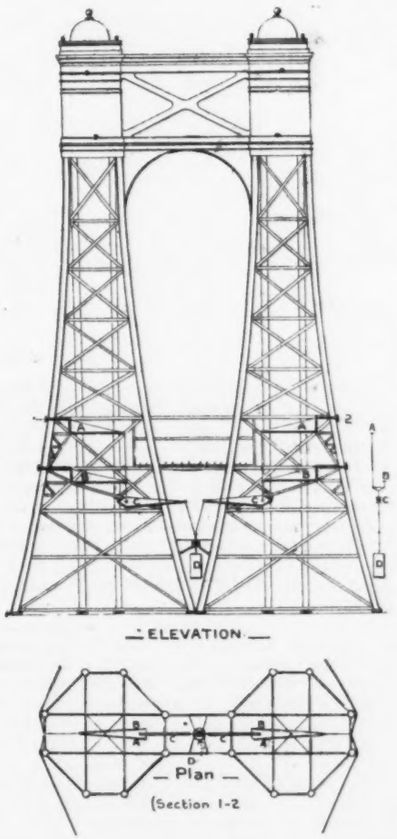
In construction, first of all, the wires forming one cable, divided into a certain number of strands, for better manipulation during the work, are to be strung over the towers in such a manner as to permit of accurate adjustment of length and tension. Of the proposed manipulation a later account in more detail will be given. For the present, it will suffice to say that the intended method seeks:

1. To make the construction of the cables in place independent of the weather, that whether cold or warm, stormy or foggy, the work may go on without interruption.

2. To adjust the wires with almost mathematical accuracy in curvature and length under permanent tension equal to, if not exceeding the maximum from the finished and loaded bridge.

3. To assure for each wire the same position in the cable from anchorage to anchorage and through all connections.

After the wires are all in place, the clamp-connections are put on first. The cable section is divided into four quarters, between which cast-iron wedges



of large size are inserted as shown in plan. A compression apparatus, capable of exerting a pressure of over 700 tons is then placed over the wires, to compress them over the wedges into the contracted shape for the clamp-connection. The compression blocks will have a face of 10 ins., so that when the cable is compressed a wire-wrapping, 3 ins. thick, may be put around the cable on each side of the compression-blocks. This done, the compressor is removed and the space filled and evened up with wrapping wire under great tension. To prevent the cable-wires from getting forced between the wedge joints, it is proposed to place thin iron sheets, bent at right angles, between them and the wedges. To prevent the wedges from slipping out of place, their thin ends will be connected and interlocked. The wire wrappings, 3 ins. thick, will form a steel band, than which a stronger and more secure cannot be made. Forged and bolted couplings of the best steel would break to pieces from the tension in the ring under the dead load alone; not to speak of the additional tension from live load. Over this thick wire-band, having a saddle like depression is placed a cast-steel coupling in two halves, which overlap each other on the sides. These couplings are provided with flanges, as shown, and the two halves are held together again by wire wrapping in the two spaces provided for it. Over these wire bands a light iron band is placed for the double purpose of preventing the wire from unwrapping and to keep water and weather out.

On the middle part of the steel couplings are placed the trunnion rings, to which the web members are connected, by merely slipping them on sideways and riveting them afterwards. The trunnion rings are in two halves, turned to size and to fit the cast steel couplings. The joint line is through the middle of the trunnions, and the two halves are held together by screw nuts at their ends and by the tightly fitted forged heads of the connecting web-members.

The trunnion ring is narrower than the space between the flanges and has oblique faces to correspond with the obliquely faced adjustment rings between it and either flange of the coupling. This arrangement is for the purpose of adjusting the trunnion rings into their final position and for an accurate adjustment of the web-members, which are not adjustable as to length. The end flanges of the cast steel coupling engage with the flanged ends of the steel mantle in such manner, that the rain water cannot enter the space under the latter. The mantle is exposed directly to the changing outside temperature and therefore has a quicker rate of expansion and contraction than the cable. The connection as shown permits the mantle to expand and contract independently of the cable inside. The dividing of the cable section into four quarters has the additional advantage that it ensures more nearly uniform temperature throughout the thick cable section, and also gives accessability for inspection and painting at any time, because the steel mantles can be removed and again placed in position without difficulty. About every 10 ft. the cables under the mantles are clamped with iron bands, and short wooden separation blocks hold the four quarters apart, and parallel between the connections.

7. THE WEB SYSTEM OF THE ARCHES.

The web system of the ribbed arches is not a matter of arbitrary choice. Again the leading consideration should be to choose that system which requires the least weight of metal. Investigation shows that for the proposed bridge the double triangular system is the best, not only in this regard, but also on account of its greater rigidity as compared with systems composed of separate compression and tension members.

All the web members of the double triangular bracing are under tension from dead load which is conducive to rigidity. All have the same length, which greatly simplifies and cheapens the shop-work.

They must all be proportioned for both tension and compression under transient loads, giving them compactness and stiffness at the same time that they are the lightest in total weight and the neatest in finish and appearance.

Where the web system is composed of either radial or vertical compression members (subject also to tension from dead load) there must be two sets of tension diagonals, for which the connection cannot be made either so conveniently or so neatly as in the former system.

Another web system having some advantages, but missing the above described, is for two cables which, instead of being concentric and parallel, have the same radius, and are placed one above the other. Here the length of all vertical members would be the same and the length of the diagonal tension members only would vary for every panel of the arch.

This latter system has the great advantage that for any deflection of the cable curve the verticals have all the same length, the diagonals alone requiring adjustment. Its use is preferable for suspended arches, having a deflection larger than one-tenth of the span, and for which the adoption of the parabolic curve is advisable to avoid excessive bending moments.

The cables connected only by the vertical members during construction can assume the curve of equilibrium, in which they can be permanently adjusted by means of the double set of diagonal ties.

In constructing the inverted arches whose curvature, as already mentioned, is to be circular, it would be very risky to make the connections so rigid, that afterwards no adjustment were possible. Even if the arches were constructed with the utmost care, the bending moments resulting from the additional weight of the platform, and from the set-

tling of the arches would be sufficiently large to cause such considerable strains that special allowance for them in the dimensioning of the arch members would be necessary.

The above described connections are adapted to avoid them, in the following manner:

The length of the cables being first accurately known, the connection points or pin-centers for the web members can be accurately divided along both cables and the web bracing can be inserted.

At every other panel point in upper and lower cable, the trunnion ring is made fast and every other is left loose, so that each cable will bear only one system of the web bracing.

The platform is then suspended from the arches and adjusted to its proper position and camber by means of the suspenders. It is clear that the lower, loose trunnion ring will slide into a position within the flanges of the steel coupling, where the entire suspended weight from the two connecting web members, will be transmitted to the fixed trunnion rings of upper cable, and the lower loose trunnion rings will take no part, or only a very small part of it. Likewise the loose trunnion rings on the upper cable will slide into a position on the cables, where they will likewise exert merely a slight radial pressure. Both cables thereby become equally loaded, which fact can be further ascertained by the action of the balancing platforms under the cable bearings on the towers.

In this position the trunnion rings are then adjusted and fixed by means of the two adjustment rings, and the arches are thereby kept free from initial bending moments.

The trunnion rings can slide around the cable to prevent torsional strains, which otherwise would occur in the swinging in of the arches from the vertical to the inclined position.

The degrees of accuracy required in the construction of the arches is hardly apparent to the uninitiated. A difference of length of one half inch in the two cables, would cause a difference of 1¼ ins. in their distance in the middle of span, so that the web-bracing would not fit.

Still, the required accuracy can be easily obtained by proper methods of work and careful inspection. The construction of the St. Louis bridge required likewise great care and an accuracy of work, unprecedented at the time. It was obtained, and the predicted results were achieved with great precision.

8. PROVISION AGAINST HIGH WINDS AND TORNADOES.

It would be extremely risky to build a very long span bridge without the most thorough and unequivocal provisions against wind forces. Although hurricanes and tornadoes rarely exert their full force over the width of a half mile, it is still safest to assume that they do, and that they descend or ascend the river right across the bridge, which must in no way be endangered by them. Ordinary slight winds, impinging on the bridge with a wave action are of more frequent occurrence. The assumption of 50 lbs. per sq. ft. on all exposed surfaces will be ample to meet the worst case.

It is a well known and safe rule that large surfaces offer a proportionately greater resistance than narrow ones, and that round surfaces offer only half the resistance of flat ones, and concave surfaces double the resistance of flat ones. The cables will have an external diameter of about 4 ft., and the round, smooth surfaces will, therefore, offer only half the resistance per unit of the flat surfaces of the suspended platform. Concave surfaces and wide ones are avoided altogether.

We see here an additional merit of the cable arches. As already remarked they will be cradled about 10 per cent. The cradling of the cables of itself would be an insufficient provision against wind pressure. It merely increases the stable equilibrium of the suspended structure, but does not protect the bridge against lateral deflections altogether. Cradling combined with proper wind cables, however, is the most efficient arrangement against wind effects that can probably ever be devised for long spans.

If the wind force acting on the arch alone is assumed to be one-tenth of the dead weight of this arch, then an inclination or cradling of one-tenth would hold it in equilbirum as against the wind.

The opposite arch, inclined towards the direction of the wind, would assist the wind in pulling the first or windward arch out of position, if it were not held fast by the horizontal wind cable. If this is done the windward arch needs no assistance from any wind bracing between the cables and will of itself resist the wind pressure. Hence it will be sufficient to stiffen the wind cables against the wind pressure on only one arch and on the surface of the suspended platform, by which is understood the stiffening girders and the floor system. The surface of the arches represent about one-half in effect, and the other half is in the suspended platform. The cradling of the arches virtually results in the saving of one-fourth of the material needed for stiffening the wind cables against deformation.

These wind cables consist of heavy twisted wire-ropes bundled into four cables, two on top of the platform and two below it. Straight wire cables are not suitable for them, they can not very well be handled and put into position without damage to them. Each such cable would be about 12½ ins. in diameter.

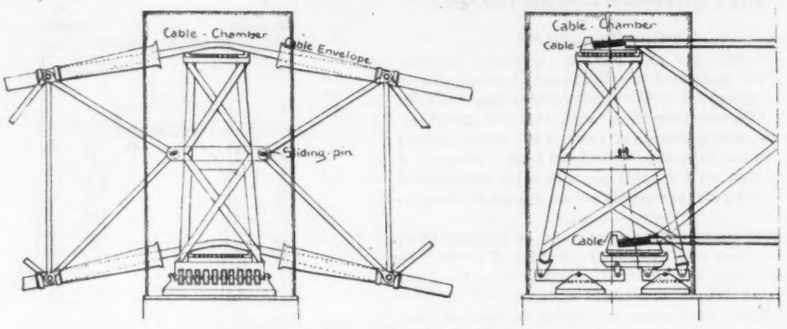


Diagram of Balancing Cable Platforms.

Wind cables as ordinarily constructed are of little use, or rather of no use. They are, as in the East River bridge, usually under the floor and supposed to be adjusted for a middle temperature; but as a matter of fact, it is not possible to tighten them at any temperature with the means usually provided, namely, with adjustable screw-end connections. Hence they remain slack, and should they ever come into action the floor would have to deflect laterally several feet to merely tighten them, long after the superstructure would be twisted out of shape and out of line.

As the curvature of these wind cables, is as a rule, very flat, they are much more affected by temperature strains than the arches. In the winter the arches, and with it the floor and wind cables, rise, somewhat tightening them; in summer the bridge sags down and the wind cables lengthened in addition. They then hang down entirely loose and useless.

Such a faulty arrangement would evidently not answer for a very long span. Better means had to be thought of to protect the bridge, summer and winter, against the least oscillation during the most violent gales. The proposed arrangement will do it in a very effective manner. By the arrangements proposed, the wind cables will be in permanent tension, equal to at least two-thirds of the maximum tension from the wind, and the tension will not change from one season to the other, whether the cables lengthen or shorten. In the accompanying diagram of the tower is shown in outline the proposed arrangement.

The wind cables pass from anchorage to anchorage around the towers, and deflect under the platform so as to secure the greatest possible deflection (in a horizontal plane) for them. At the towers the bundled cables flatten out to a ribbon of single ropes pressing against upright saddles on vertical roller supports.

Between the tower columns the wire ropes are drawn in to form a funicular machine and are attached to a lever arrangement in the towers as shown. By this means a permanent great tension in all four cables is produced, and their sagging prevented. A common weight of about 100 tons (stone or pig iron) in each tower will be so proportioned as to produce a permanent tension of 1,500 tons in each cable.

Let now a gale blow across the bridge, which would bring the two concave cables (concave towards the wind) into action. It is clear that if each cable were in tension from separate weights that they would balance each other, and the bridge would deflect sidewise in spite of them. But with the arrangement as shown, the windward or concave cables resisting the wind pressure will immediately be brought into greater tension, because their corresponding levers must lift the common weight, and that will slacken the lee cables. Therefore, no matter what the direction of the gale and the season of the year may be, all the wind cables will be ready for instantaneous resistance. They will also otherwise greatly increase the stable equilibrium of the suspended platform, first by reason of their weight, far below the center line of gravity of the mass between towers, and secondly, because their permanent tension will do away with any looseness or oscillation of the floor or girders.

A gale striking the bridge from below, (considered the most dangerous action of wind) will be resisted by the immense weight of the suspended structure, by the inherent rigidity of the girders and arches, and by the permanent tension of the wind cables. The wire netting over the floor will leave only the narrow surface of the stringers, floor-beams and girders, for the wind pressure to act upon and their common area is much less than the area exposed to a gale blowing horizontally at right angles to the bridge.

The absolute safety of the bridge against the action of the most violent tornadoes ever experienced, will be thus assured.

9. THE ARCHITECTURAL FEATURES.

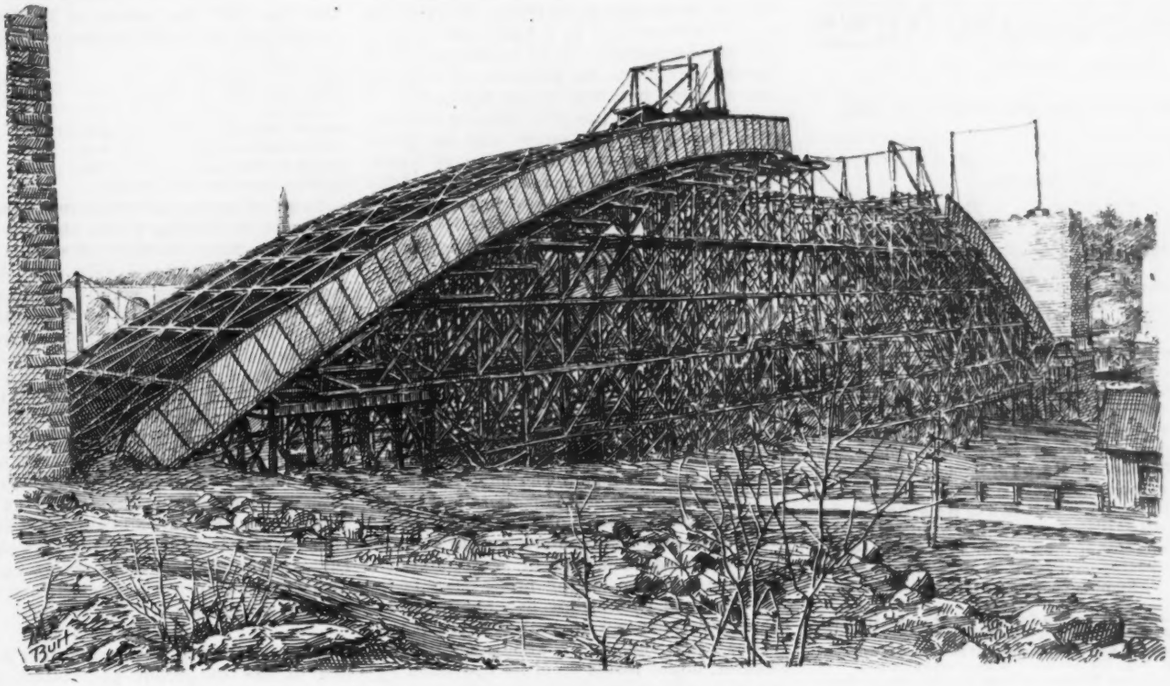
The architectural excellence of the bridge was considered of the highest importance, and it was sought to obtain it in a natural manner without attempts at ornamentation.

There is an often repeated phrase, that correctly designed structures have an innate architectural beauty, requiring no adornment, unless perhaps that of a well selected color of paint.

The Whipple truss bridge is a correctly designed structure; therefore according to the hackneyed phrase it should be, and by many actually is regarded, as beautiful and hence a series of such trusses strung over a row of piers for spans of different lengths, and with trusses of different heights, should represent an aggregation of beauty most gratifying to the beholder. Others have it that a curved chord is beautiful, and that somehow it gives distinction and meaning to a construction, which it could not have without it. It appears that crude notions of beauty differ very much for bridges.

In former times the engineer and architect were one. Without going back to the great masters, who designed and built the great cathedrals of Europe for instance, the influence of the former combination of the professions is manifest in our own era of metal-bridge building. The graceful suspension in Buda Pesth (without question the finest existing specimen of this class of bridge-architecture), the early bridges in Paris, and a few over the River Rhine were built by engineer-architects, when the field of engineering did not yet justify exclusive devotion to one specialty, to the neglect of other branches of the science of building. But for the taste and stubborn persistence of the late Capt. EADS, the St. Louis bridge would have been built so as to be not the finest specimen of a metal arch-bridge architecture in this country, which it is, but on the plans of the old Omaha bridge, now worn out, and soon fit only for the scrap heap.

It is a noteworthy fact that every large meta



Manhattan Bridge; Shore Span, showing Falseworks.

bridge which has been built with due and intelligent regard to its architectural appearance, has also received so much care and minute attention in the purely engineering features of construction that they have outlasted the mere utility structures alongside of them and, in most cases, will outlast those of the same class constructed at the present time.

The standpoint of utility has, in our time, become with many almost the only professional point of view for judging of the merit of engineering work, so that the incentive for better things is wanting. A good deal of the blame is with the engineering schools. There is not one text book, to the author's knowledge, in the English language, on "Bridge Architecture," and no attempt is made to teach the students even the rudiments of good designing. It is thought to be of more consequence to furnish an elegant graphical solution of the strains in a polygonal truss, or in the invention of a new formula for the very least weight of iron in a bridge, than to design with a decent regard for pleasing appearance, and for the feeling of fellow men and the opinion of posterity.

Some time ago the author was told by a member of this Society, and a railroad manager of national reputation, that every time he hears of a new project for a larger bridge or for an elevated railroad, he experienced a fear that another of the common hideous looking structures will be going up; and another gentleman, also a well-known man of large affairs, added rather metaphorically, that if he had his way he would put under penalty every promoter and engineer guilty of creating some of these recklessly vulgar structures, as he called them.

The author felt compelled to say in defense that the engineers cannot always do as they please and that public sentiment must be educated in this respect, to sustain them in efforts for better things. When we shall have progressed that far, it will become impossible to fill up the streets of a great city with such a shameful conglomeration of iron structures as are found in New York and Brooklyn.

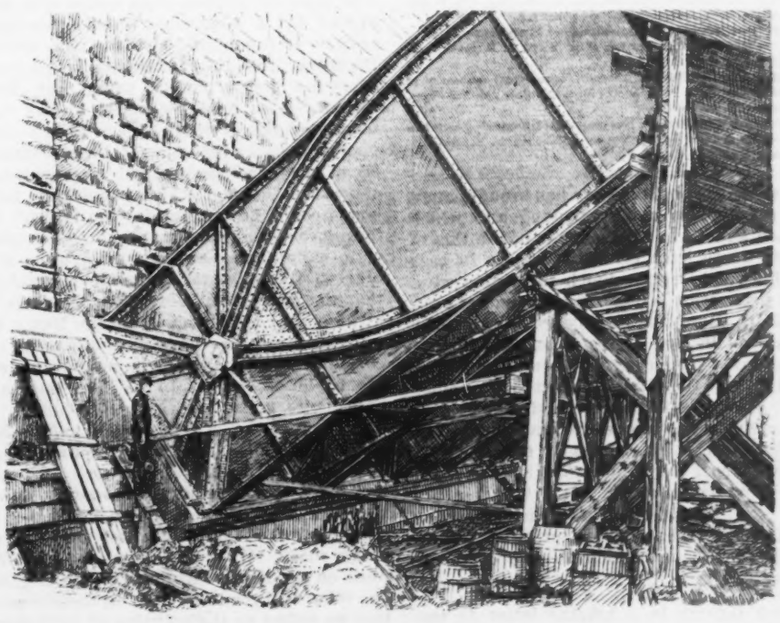
This digression may be pardoned in view of the importance of the project. It is certainly true that if the New York Harbor, acknowledged to be the most beautiful in this country, should be defaced by a utility bridge of shabby appearance, it would be an unpardonable offense against the civilization of mankind. A pleasing architectural appearance of the bridge was therefore held to be worthy of as much study as the engineering features, and the design aims to combine them in the best manner attainable out of a variety of designs made for the purpose.

The Manhattan Bridge.

Our illustrations of the shore span of the Manhattan bridge, over the Harlem river in New York, shows the condition of that span somewhat more than one month ago. The arch was closed on Dec. 21, and at the present date 14 of the supporting columns, floor-beams and stringers are in place to support the roadway columns each side of the crown of the arch.

In the river span (to the right in our illustration) the falseworks are erected and the arch ribs are being built. On the west end of this span the first arch member, or about as much as is shown in our smaller cut, is now in place; on the east end the ribs extend outward about 40 ft. for each of the six arches.

Some idea of the general proportions of these 500-ft. arch spans can be obtained from the smaller illustration, with the workman serving as a natural scale. As we will shortly give some of the details of this arch it will suffice now to mention that the hinge pin is 18 ins. in diameter and 35 ins. long. These pins are made of forged steel and rest in forged steel bearing blocks—neither pin nor block being "cast-iron" as supposed by some. The arch rib is 13 ft. deep, from out to out, and is made up of plates, 6×6 in. angles and a ⅝ in. web-plate, except for the skew-back segment which has a ¾ in. web.



Manhattan Bridge; Skewback Segment and Hinge.

The erection of these spans has been very rapid when their mass is considered and the work is of a nature that reflects much credit on the engineers who designed it, and the Passaic Rolling Mill which manufactures and erects it.

"LAST year was phenomenally prosperous, and I see no reason why 1888 should fall short of 1887," said Vice-President GREEN, of the Pennsylvania Railroad.

ENGINEERING NEWS

TRIBUNE BUILDING, NEW YORK.

VOL. XIX., Saturday, February 4, 1888.

D. McN. STAUFFER. A. M. WELLINGTON, EDITORS.

GEO. H. FROST, - - - BUSINESS MANAGER.

Subscription. — UNITED STATES AND CANADA, $5.00 *per Year; $2.50 for Six Months; $1.50 for Three Months; Single Copies, 12 cents.* FOREIGN COUNTRIES, $6.56 *per Year, or 3 cents per number additional.*

Drawings and Photographs *of all new engineering works or designs, large or small, of interest from their magnitude, novelty or originality, as well as newly adopted* **Standard Plans** *for engineering structures or details, rolling stock, etc., are always desired for early publication. Also* **Brief Technical Notes** *of the cost or manner of executing work, tests of materials, machines or other new devices, and* **News of New Construction** *of all kinds.* **Letters** *for publication must be accompanied by the name or card of the writer.*

Coming Technical Meetings.

Engineers' Club of Philadelphia, Pa.—Regular meeting, Feb. 4. Secy., Howard Murphy, 1122 Girard St.

Engineers' Club of Kansas City, Mo.—Regular meeting, Feb. 6. Secy., Kenneth Allen, 19 Deardorff Building.

New England Railroad Club, Boston, Mass.—Regular monthly meeting, Feb. 8. "Wheels and axles, and their relation to the track." Secy., Francis M. Curtis, Boston & Albany R. R. Passenger Station.

Civil Engineers' Club of Cleveland, O.—Regular meeting, Feb. 14. (Mechanical Engineering branch of the club). Secy., C. O. Arey, 31 Blackstone Building.

American Society of Civil Engineers, New York.—Regular meeting, Feb. 15. Sec., John Bogart, 127 E. 23d St.

Engineers' Club of St. Louis, Mo.—Regular meeting Feb. 1. Secy., W. H. Bryan, 709 Market St.

Boston Society of Civil Engineers, Boston, Mass.—Regular meeting Feb. 15. Secy., S. E. Tinkham, City Hall.

American Institute of Mining Engineers.—Annual meeting at the Institute of Technology, Boston, Mass. Feb. 21 to 25. Secy., A. Raymond, Burling Slip, New York City.

American Society of Mechanical Engineers.—Meeting at Nashville, Tenn., in April or May. Secy., F. R. Hutton, 280 Broadway, New York City.

Master Car Builder's Association.—Next convention at Alexandria Bay, N. Y; commencing June 12. Secy., M. N. Forney, 45 Broadway, New York City.

American Railway Master Mechanics' Association.—Next meeting at the Thousand Islands, N. Y.; June 19. Secy., Angus Sinclair, Chicago.

THE late fire on Broadway has brought anew into prominence one great danger to which firemen should be no longer exposed, that of sudden death from electric currents in case they happen to cut or touch the wrong wire. Their occupation is hazardous enough at best, and there should be established in every city a rule that in case of fire at any locality all dangerous electric currents should be ordered off all wires in the vicinity, from the same office which sends out the alarm, and at whatever temporary inconvenience to individuals. If the electric light companies do not like this inconvenience, they can escape it by placing their wires underground, but it is monstrous that men whose occupation is dangerous enough at best, should be in terror of this unseen danger against which no care of theirs can guard.

MAYOR HEWITT, in a lengthy letter to the Board of Aldermen, outlines a scheme of reform in New York affairs that has much merit, especially in the matter of the better condition of our streets and the improvement in methods of traffic. The radical feature in his project, and one on which there is something to say on both sides, is the practical extension of the New York Central Railroad to the City Hall by a tunnel; the extension to be built by the city and operated under a rental by the railroad company. The route is by way of Elm street, the estimated cost is $10,000,000, and the rental to be paid the city is $500,000 per annum for 35 years. He proposes to raise this amount by a 3 per cent. loan, so the rental would provide for a sinking fund of $200,000 per year. He proposes as a better plan still (but in this we do not agree), that of the four-tracks to the City Hall, two tracks shall pass down Elm street and two down Broadway, these systems uniting at Union Square and City Hall Park. At the end of the 35 years the road is supposed to be paid for, and it then passes free of debt to the city, to be either again leased or otherwise operated as circumstances may dictate.

For this project it may be said that the City of New York can borrow money at much lower rates than any new corporation, and consequently the first cost should be much less and the traveling public should receive the benefit in a minimum of fare paid. The objection comes in the proposed management of this traffic by a corporation not particularly noted for its liberality to the public or attention to its comforts. This corporation would have a fixed rental to pay, is supposed to furnish its own rolling stock and to operate the road for a fixed term of years; and the incentive to make all the profit possible in that time will be a strong one regardless of the convenience and general comfort of the parties using the line. The same effects, however, might result from its operation by the city, and even worse if politics were mingled with its management, as would very likely be the case. An increase of rapid transit facilities is greatly needed, but there may be some doubt about Mayor HEWITT's plan being an altogether unmixed blessing.

We believe that the City of New York should control, not only this, but all other routes of corporation traffic on its streets to the extent of at least fairly sharing in the profits arising from such use; rather than giving free right-of-way to a company, which practically pockets all the profits, as is the case with the Broadway road, for example, which earns every few months its total actual cost. But if the city is to lend its credit to any rapid transit scheme, it would appear to us a better plan to open the list to general competition as far as the construction and management is concerned. Under these conditions heavy bonds could be secured for the faithful performance of contract, either in the construction or in maintenance and operation, on lease or otherwise. And as far as the fact is concerned that the New York Central now controls the exit from the city, upon which the Mayor lays especial stress, we have no doubt that that corporation will be happy to make terms with any feeder or feeders to its lines and carry passengers, no matter where they come from. Long before the 35 years would expire, New York would demand several routes besides that proposed in Mayor HEWITT's letter; in fact a four-track road on Elm street, now in operation, would be taxed to its utmost in caring for the simple overflow from the existing roads. We would soon need another route on the North River side of the city, and one other on Broadway. It is for these reasons that we object to the splitting of his present project and the laying of double tracks on Elm street and Broadway, instead of putting down a four-track road on each as time will doubtless demand.

We are much more heartily in accord with the Mayor's proposed street improvement by a $3,000,000 loan, and his suggestions concerning the absolute department control of all manner of breaking into the street surface. This latter evil is really at the bottom of all our troubles in regard to bad pavement. As shown by an exhibit in the Mayor's letter, in the year 1887, the streets of this city were broken into for the following purposes:

Gas mains laid		98 Miles.
Electric subways		25.58 "
Water pipe laid		15.42 "
Sewers built		7.12 "
Steam pipe laid	4,791 Lin. ft.	
Salt-water pipes	3,790 "	
Street railways	10,500 "	
House connections, total number		17,973

This foots up to a total of more than 150 miles of trench of varying width, and does not include the many miles of excavation for repairs to water pipes, sewers, etc. With the exception of the last mentioned repairs all of this work is now done by practically irresponsible parties, who only seek to bury some appliance of their own, and have little or no regard for the after condition of the broken street. It is this condition of affairs that the Mayor and the Commissioner of Public Works very properly wish to correct, and every good citizen must wish them success. There would undoubtedly be opposition to any such reform from powerful corporations; but, as Mayor HEWITT says, there are no such things as vested rights which can interfere with the power of the community to do those things which are essential for its growth, its safety and its progress in civilization.

Along with better pavements must come an end to the dangerous and public-defying center-bearing rail on street railways, only used to compel the citizens to keep off of a portion of their own territory over which the railway corporations assume an absolute and undivided right-of-way. The Mayor points out this evil forcibly and also that the very existence of this form of rail is in defiance of the law, and he believes that a simple ordinance of the Common Council could compel the companies to replace it by a rail more in conformity with that used in English and Continental cities. Since the difference in climate may require some modification, at least, in the center groove rail which Mr. HEWITT recommends, he wisely suggests that any improved form of rail be first given a thorough trial, (on the Broadway route preferably), before its adoption is enforced on all the companies. Any first-class street railway pre-supposes a much more solid foundation and better and more costly substructure than any of our street railway companies now use; and the choice of rail is somewhat dependent upon this foundation and the general condition and maintenance of the adjoining street surface. The improvements should all move together.

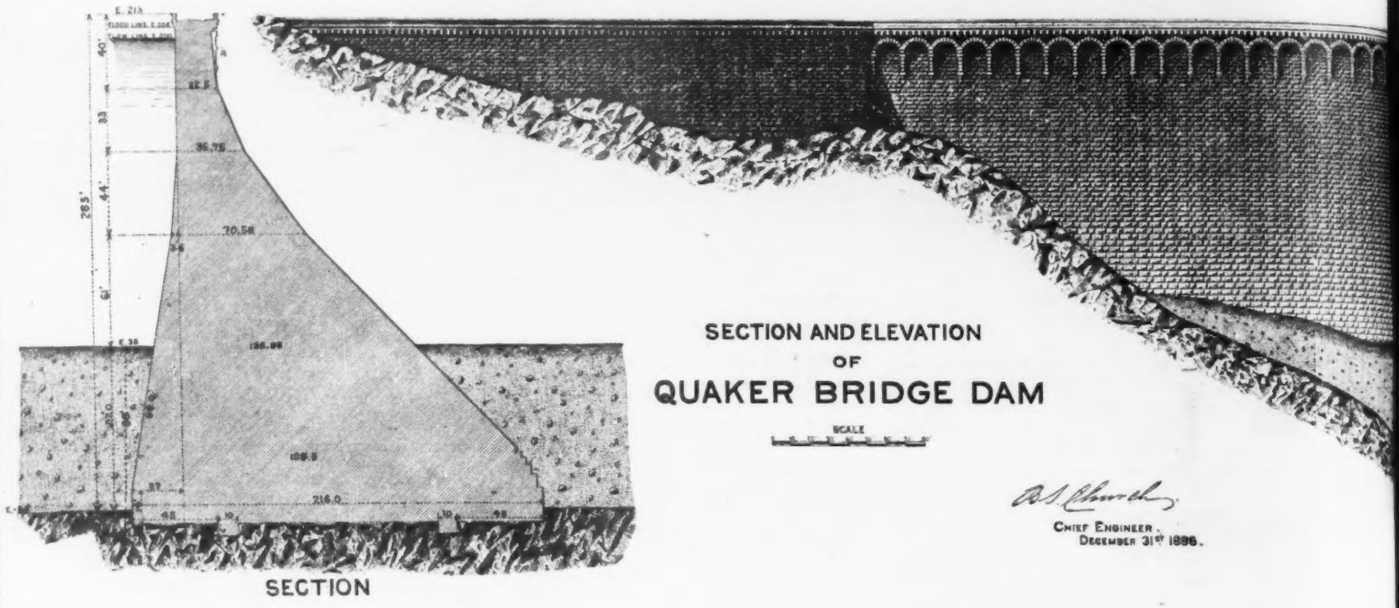
IF Mayor ROCHE, of Chicogo, is correctly reported in the *Tribune* of that city, engineers must be very scarce thereabouts. He has lately visited New York "for the purpose of investigating the various pumping systems," so that the authorities could adopt pumps for the new works "with some intelligence." The reason for the Mayor's visit, as expressed by himself is that—"I had no man I could send to make the examination, so I went myself." He further says that he visited a large number of works and—"made a careful study of the merits of the respective systems, and think we shall be able to get a good plant at a comparatively small price".

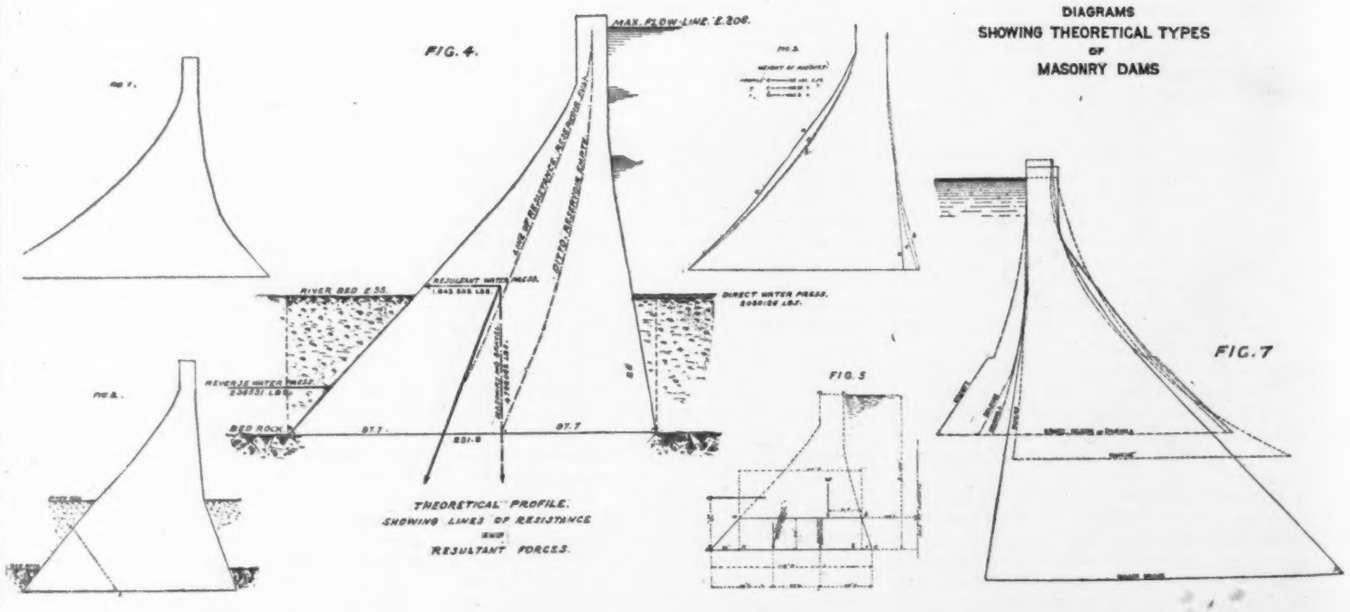
WHILE the intentions of Mayor ROCHE were doubtless good, we question whether his engineering experience and ability to make an intelligent choice between the various pumps and "systems", equalled the said intentions. We particularly object to the inference to be drawn from his little speech—that because an engineer was not then attainable, any Mayor or other layman could do the engineer's work

THE QUAK BR

Accompanying Report of A. Fteley, *Consul Engi*

NEW CROTON DUC

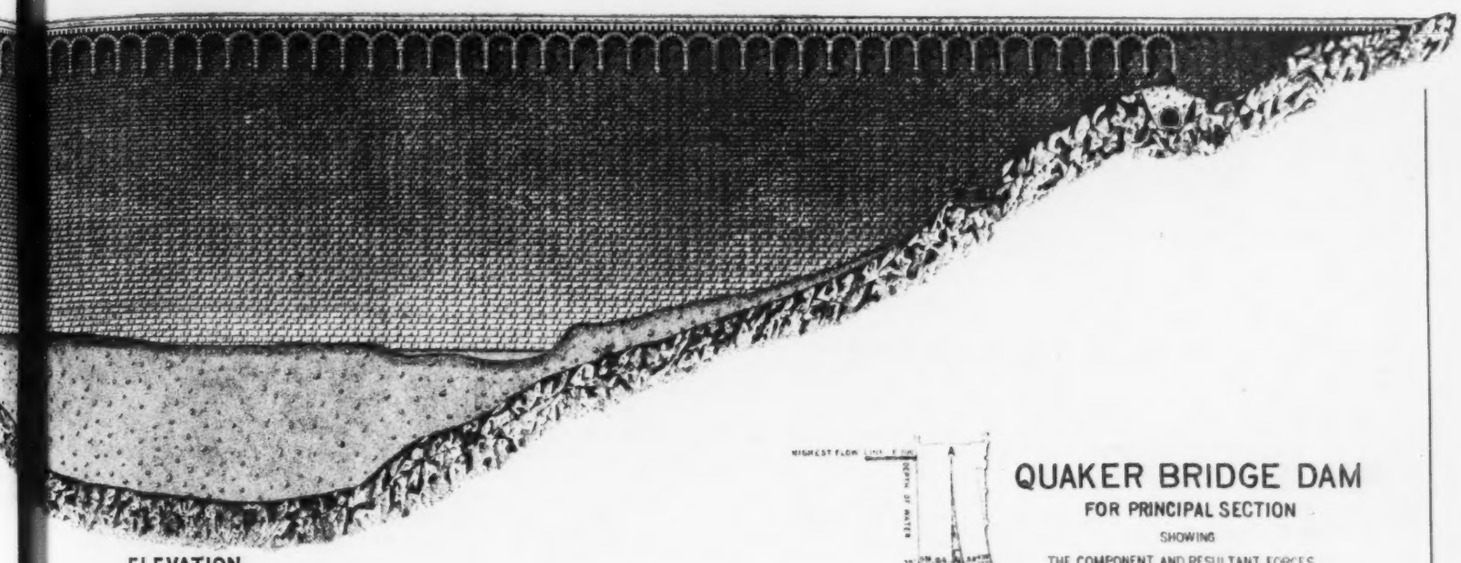




K BRIDGE DAM.

Engineer, to B. S. Church, *Chief Engineer,*

DUCT, NEW YORK.



ELEVATION

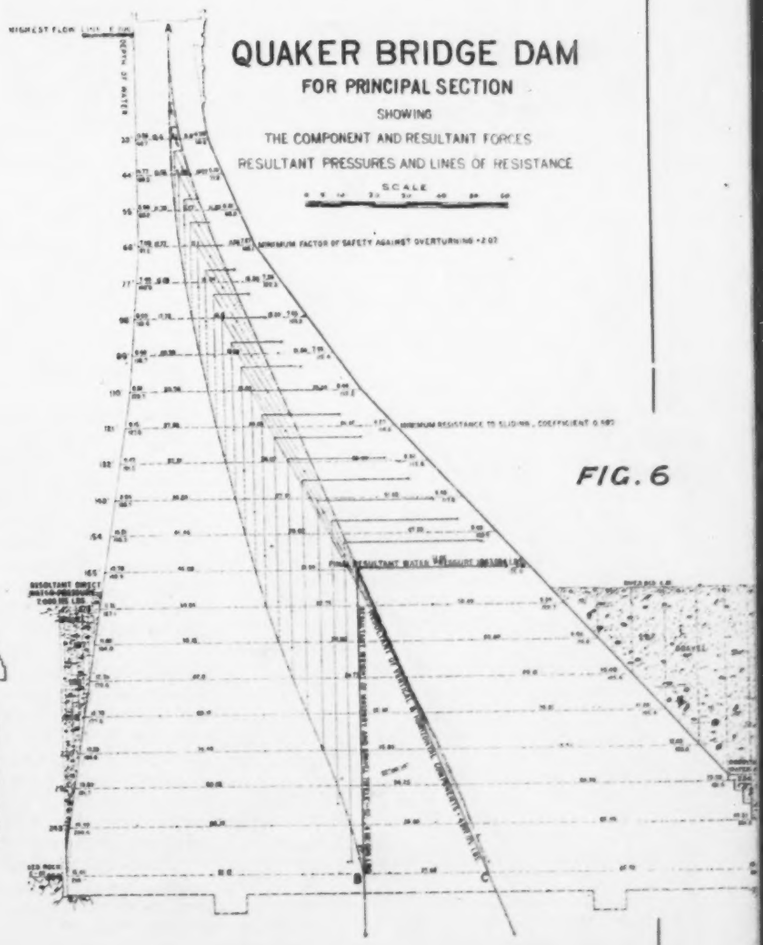


FIG. 6

DIAGRAMS
SHOWING COMPARATIVE SECTIONS
OF
SEVERAL HIGH MASONRY DAMS

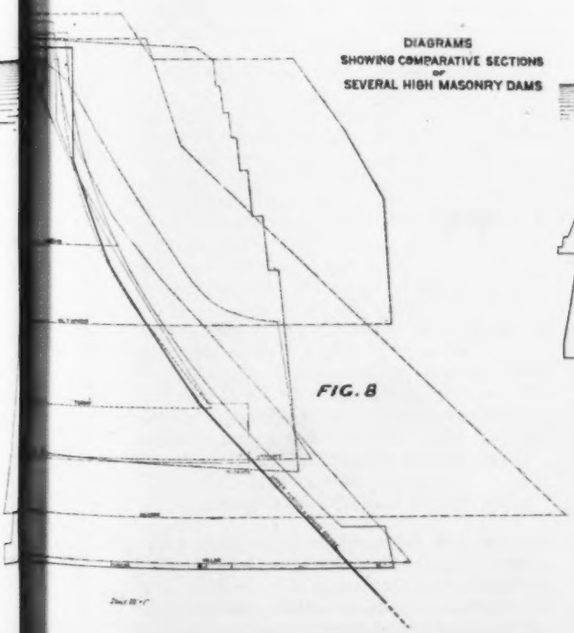


FIG. 8

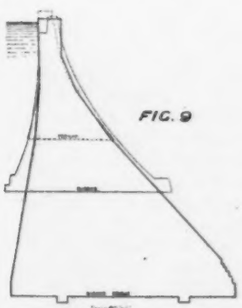
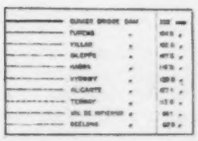


FIG. 9



equally well. It would have been much better for his Honor to have told the truth and said that—if he did any work of value in New York—he discussed comparative prices of pumps and examined into the standing of the various companies and their ability to fulfill a contract. It is to be earnestly hoped that Chicago will have better data upon which to purchase its additional pumping plant than the "careful study of the merits of the respective systems" by its Mayor. Chicago has among its citizens many capable engineers, and if it really was a question of comparative merit that was to be decided, the services of one of these men could have been secured for a reasonable sum, we have no doubt.

THE *Railway Age* keeps a very useful record of foreclosure sales and receiverships of railways, showing the following aggregates:

Summary of Foreclosure Sales for Twelve Years.

Year.	No. roads.	Mileage.	Capital stock and bonded debt.
1876	30	3,810	$217,848,000
1877	54	3,875	198,984,000
1878	48	3,906	311,611,000
1879	65	4,909	243,288,000
1880	31	3,775	263,882,000
1881	29	2,617	127,923,000
1882	16	867	65,426,000
1883	18	1,354	47,100,000
1884	15	710	23,504,000
1885	22	3,156	278,494,000
1886	45	7,687	374,109,000
1887	31	5,478	328,181,000
Total in 12 years.	404	42,174	$2,480,370,000

The receiverships have been kept for a much shorter period, but show the following:

Summary of Receiverships for Four Years.

Year.	No. roads.	Mileage.	Bonds.	Capital stock.
1884	37	11,038	$407,071,000	$307,684,000
1885	44	8,286	192,433,000	187,027,000
1886	13	1,799	39,231,000	31,115,000
1887	9	1,046	42,887,000	47,431,000

Of the total for 1887, $35,948,000 was made up by a single road, the Chesapeake & Ohio. Except for this the total will be seen to be quite small. The number of roads in default on interest is much greater than the number which have receivers appointed. In October, 1884, for example, there were nearly 16,000 miles of road in default, or 9.12 per cent. of all the railway bonds of the country, while only 11,000 miles had receivers appointed, and only 710 miles were sold under foreclosure.

A goodly number of roads appear twice or more in the above table of foreclosure sales, but that nearly one-third of the *present* total mileage of the United States, and over 40 per cent. of the average total mileage, should have been sold out under the hammer in twelve years is a striking commentary on either the recklessness of management or the hazardous nature of railway property as an investment, or both. To a very large extent the foreclosures result from piling up obligations for which no solid cash basis ever existed, but to a large extent they are also due to unavoidable uncertainties of such investments. Never, we believe, were financial obligations piled mountain high with more sincere belief that it was expedient and necessary to incur them, and with more plausible arguments in their favor, than in the case of the Reading road, but the result was disastrous enough. We have no doubt that some of the great Western agglomerations will end the same way, although perhaps not for some time to come.

The Design of the Quaker Bridge Dam.

The design and construction of a dam exceeding by nearly 100 ft. the highest heretofore constructed in the world cannot but be an object of the greatest interest to engineers, as well as an event in the history of engineering. In the whole world there are only 17 dams exceeding 95 ft. in height, the amount by which the Quaker Bridge *exceeds* all other dams, and only 23 exceeding 67 ft., if we may accept as complete the table given in connection with Consulting Engineer FTELEY's report, the first part of which we give in this issue. (The table itself was given in our issue of Jan. 7). The highest dams heretofore have been six of nearly equal magnitude 160 to 170 ft. high. The Quaker Bridge caps them all with 265 ft.

Of the whole list of great dams, except the little known San Mateo, now building in California, and the comparatively small Boyds' Corners dam (75 ft. high) there is not one in this country, so that our engineers have been compelled to draw wholly upon foreign practice for precedents. Even had this not been so, the unexampled magnitude of this new work, and its unexampled importance as well (for it will be by far the most important as well as the largest in the world) would have demanded the most careful investigation, and this has certainly been had on behalf of the Quaker Bridge project. As Chief Engineer CHURCH well says in his report (ENGINEERING NEWS, Jan 14, 1888:)

"The world's experience in the designing and construction of great dams, together with the investigations and opinions of the highest authorities, in Europe and America, were collected and considered in the plans prepared and presented to the Commission."

Besides the present able staff of engineers Messrs. E. S. CHESBROUGH, JULIUS W. ADAMS and ISAAC NEWTON formulated the original plans some time ago, and various other engineers of prominence have had more or less to do with the preliminary studies. Certainly no great dam was ever before so carefully studied, and we may be sure that, despite its magnitude, no such amount of study would have been given to it had it not been so vital a matter that it should not fail. For although New York gets along now after a fashion without it (by chronically throttling the water mains) and will be able to do so for a time even after the completion of the new aqueduct next year, yet the day is near at hand when a failure of the dam would bring about the terrible catastrophe of a prolonged water famine in New York, which might last for months or years. This necessitates discussion and scrutiny of every detail; but, had the very same dam been projected in Siam or Peru or Madagascar, the chances are that it would have been turned over to one or two engineers on the ground who would have quietly worked out a design according to their own notions and built it without let or hindrance.

Perhaps for this reason a question has been raised in respect to the Quaker Bridge dam, which does not seem to have been a subject of much discussion in designing any other dam, or even in this one until recently; whether the dam should be built on a curve or straight. It has been urged by some of the Aqueduct Commissioners and others that the dam should be built on a curve so as to act as an arch, and the principal subject of discussion in the two reports which we are republishing is this question.

We do not recall the exact arguments by which the curved form was first advocated, but if we may judge from the response, it was that by adopting it the dam would resist the water pressure solely or wholly as an arch, and not primarily, if at all, by its dead weight, as is the sole reliance in a straight dam, of necessity. This argument, if it was in fact that advanced, is answered by Chief Engineer CHURCH with crushing force, as follows:

1st. "When the section of the Quaker Bridge dam is of a required area of cross sections to resist reservoir pressure by its own weight, and is then built on a curve, the dam cannot act as an arch.

"Such a section will closely approach the shape of a right angle triangle, with its apex at the surface of the reservoir.

"The water pressure against it, from a full reservoir, will be nothing at the surface, and as the pressure increases, at successive depths, a corresponding thickness of masonry in this section increases in due proportion down to its base to sustain such pressure.

"In order that arch thrust may act to transmit pressure to the hill-sides, an elastic movement of the masonry, resulting from water pressure, must, of necessity, take place to produce such thrust.

"This approximate triangular section of masonry is of a form that will best resist and practically stop such elastic movement, in the plane of the cross-section that transmits arch-thrust. It must be remembered that the possible elastic movement of the vertical transverse cross section is insignificant when compared with the longitudinal elastic yield through so long a dam.

"In short, the stiffness of the triangular cross-section prevents the far greater longitudinal elastic movement required to permit appreciable arch-thrust to reach the hillside.

"Therefore, a long, curved dam with a gravity section will resist hydraulic pressure against it by its own weight, and not by arch action."

A careful demonstration of the truth of these positions is then given, which, as it appeared in full in our issue of Jan. 14, we need not repeat, except to call attention to the fact that from first to last the comparison is only between "a straight dam resisting pressure by its weight only" and "a dam in the form of an arch *transmitting thrusts to the hill-side*." In respect to this the conclusion stated is (italic ours):

"For the Quaker Bridge structure, the *strength, economy and safety* of the straight dam, *so far* exceeded what was obtainable by the curved form that I can only account for the construction on a curve of so many large modern masonry dams, from the fact that *only within a few years has the question begun to receive the attention it deserves from trained and experienced hydraulic engineers and authors.*"

This is probably correct enough if the comparison be made only between an *arched* dam, acting as such, and a straight gravity dam. We can see no ground for questioning the entire accuracy of the demonstrations and conclusions given as to that specific question; but after all, the *practical* question is not between a pure arch and a pure gravity dam, but between a curved dam acting as an arch or in any other way, as compared with a straight dam, and it appears to us that there are certain cogent arguments in favor of a GRAVITY DAM WITH A CURVED FACE, INSTEAD OF A STRAIGHT FACE, which are not discussed in the report, and should apparently lead to a reversion of the conclusion as to the *form* of the dam, although not as to its mode of action under normal conditions.

We are inclined to believe that it is these arguments, rather than lack of attention to the theory of the subject, which has caused so general a preference for a slight convexity in high masonry dams. It is at least worth while to summarize past practice. With the exception of the small Boyds' Corners dam (75 ft.) the Lozoya (105 ft.), a Spanish antique, and the Vyrnwy (134 ft.) in Wales, controlling the Liverpool water supply, every straight dam in the world of over 68 ft. is in Algeria, and the total list of them, arranged in order of height, is as follows:

Existing Straight Dams of the World.

	Height. Ft.	Length. Top.	Length. Bottom.
Vyrnwy, Wales	*134	1,050	—
Hamiz, Algeria	135	331	131
Grancheurfas, Algeria	131	508	164
Habra, Algeria	*129	1,060	—
Lozoya, Spain	105	291	200
Djidjonia, Algeria	84	196	—
Boyds' Corners, New York	*75	670	—
Helat, Algeria	68	328	—
Average, 8 dams	107.6		

[*The starred heights in this and the following table are to high water; the others to top of dam.]

It does not follow that because the Algerian dams were for comparatively unimportant purposes in an unimportant country that the engineering skill employed was likewise inferior, but the probability is increased that they were copied one from another in that

respect and that the ideas of one or two men were decisive and were little discussed. The Vyrnwy is the most important precedent for a high straight dam. This was fully described in our issues of Jan. 30 and June 19, 1886, and we find no record of the question of straight *vs.* curved plan ever having been raised concerning it. It is of peculiar and very massive cross-section, to provide, apparently, for a heavy overflow by an adequate apron, superlatively well built of "cyclopean rubble," and we may note in passing that 3 in. cubes tested up to 808 tons per sq. ft. and 9 in. cubes of concrete to "at least 187 tons per sq. ft. after one year, increasing thereafter," the cement mortar doing even better.

On the other hand, the list of high curved dams is as follows:

Existing Curved Dams of the World

	Height. Ft.	Length. Top	Length. Bottom.	Radius. Ft.	Middle Ordinate.
San Mateo, Cal.	170	700	——	637	——
Furens, France.	*167	3 8	30	827	16.4
Villar, Spain.	*167	546	——	440	——
Puentes, Spain.	164	925	70	polygonal	
Gilleppe, Belgium	*160	1.2	269	1632	45.
Ban, France.	*160	——	——	——	——
Alicante, Spain.	134	190	30	351	13.
Komatou, Bohemia,	*125	410	25	820	25.
Zola, France.	*1.2	205	23	158	37.7
Ternay, France.	*118	——	——	1312	——
Val de Infi'no, Spain.	116	330	67	350.?)	(polyg.)
Nijar, Spain.	102	355	83	——	——
Elche, Spain.	76	240	60	205	——
Almanza, Spain.	68	292	45	86	——
Geelong, Australia.	67	226	——	300	20
Average, 15 dams	121.1				

[*The starred heights are to high water: the others to top of dam.]

Arranged in order of height the dams may be classified as follows;

San Mateo,	170		Komaton,	125	
Furens,	167		Zola,	122	
Villar,	167	7 dams all curved.	Ternay,	118	5 dams all curved.
Puentes,	164		Val del Inf'o,	116	
Gilleppe,	160		Nijar,	102	
Ban,	160				
Alicante,	134				
		4 dams			
Hamiz,	135	strai't	Lozoya,	105	4 dams
Vyrnwy,	134	all but	Djidjonia,	84	stra't. 2
Granch'as,	131	1 in Al-	Boyds' Corners,	75	Algerian
Habra,	129	geria.	Helat,	68	
			Elche,	76	3 dams
			Almanzar,	68	all
			Geelong,	67	curv'd.

Here we see that the *seven* highest dams, and excluding the Vyrnwy and three Algerian dams the *twelve* highest are all of curved plan, although only one of them, the peculiar Zola, are of the *arch* type, discussed in the reports to the Commission; *i. e.* rely upon the arch form for their normal stability.

This past practice indicates a decided preference, not for an *arched* dam, which has been attempted in only one case (although it is worthy of note that that attempt was successful) but for a curved face instead of a straight in gravity dams. We feel compelled to believe that this has been for the following reasons, and not merely from ignorance.

In the first place if we conceive the curved dam likewise to be normally a gravity dam, the terrific comparison in Fig. 1 (reproduced

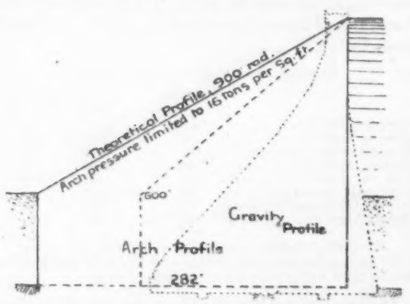


Fig. 1.—Reduced copy (with line marked 600 added) of "Comparison of Gravity Profile of Quaker Bridge Dam with Theoretical Profile of an Arched Dam" from Report of Chief Engineer. ENGINEERING NEWS, Jan. 14.

from our issue of Jan. 14) falls to the ground. It is no longer necessary in any case to adopt a larger cross-section for a curved dam than for a straight, since the same section has the same stability in each. In fact, the fearful looking trapezoid in Fig. 1 can hardly be said to be the "theoretical profile of an arched dam" in any case, for the reason that such a dam *must* act as a gravity dam likewise, although a curved gravity dam may not act as an arch. We can therefore in no contingency, either theoretical or practical, need a larger section for a curved dam than straight.

It then ceases to be true that the straight dam is from any point of view "far" cheaper than the curved, as it certainly is not "far" stronger, nor stronger at all. Admitting for the moment only (what is not true) that the cost of the dam will be as the length of crest, the latter is increased by only a moderate per cent. even by quite short radii and large versed sines, as will more clearly appear from the following table, which is shown graphically in Fig. 2. A radius of 900 ft. which is the one selected for comparison, increases the length and cost of the crest and roadway alone only 5.37 per cent.

Comparative Lengths of Crests, etc., for various Straight and Curved Dams spanning a Valley 950 ft. across (substantially that of the Quaker Bridge; see Fig. 3).

	Length of crest, ft.	Excess over Straight. Feet.	Excess over Straight. per ct.	Versed. sine, ft.
Straight Dam	950	——	——	——
Curved, 2,000 ft. rad.	958.8	8.8	0.92	57
" 1,500 " "	966 9	16.9	1,78	77
" 1,200 " "	976.7	26.7	2.81	98
" 900 " "	1001.	51.	5.37	136
" 800 " "	1017.	67.	7.05	156
" 700 " "	1044.	94.	9.80	186
" 600 " "	1096.	146.	15.37	233

The crest of Quaker Bridge dam, although 1350 ft. long in all, is only some 900 or 950 ft. long over the valley proper, as outlined in Fig. 3. In Fig. 2 are shown arcs for the various

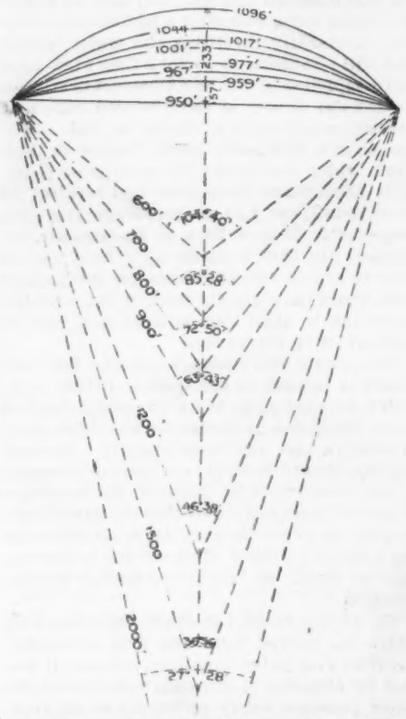


Fig. 2.—Comparative Lengths of Chord-line and Arcs of various Radii, Spanning Quaker Bridge valley.

radii above, even a 600 ft. radius including but little over a right angle of central angle. Hence we may note in passing that it is not necessary to adopt so large a radius as 900 ft. for a comparison of curved and straight dam; 600 ft. would have sufficed; and since the strains for otherwise equal conditions are inversely as the radius, this at once reduces the formidable trapezoid of Fig. 1 by about one-third (really somewhat more) as shown by the dotted line marked 600. We then have the following comparison:

	Area Sq. ft.	Radii. Face.	Radii. Toe.
Gravity profile	26.219	——	——
Arch profile, 600 ft. radius	34,155±	600	412±
" " 900 ft. "	51.233	900	618

This alone brings the arch type down to limits which do not make it seem like a mere absurdity. The area is only 40 per cent. greater instead of nearly double, while the stability is nearly 2½ times greater, as thus: Call the stability of the gravity dam 1;—the arched dam has a gravity stability of 1¼ to 1½ in any case, because of its greater section, but it has *in addition* an arch stability 1, when and if it is called into action by a deficiency from any cause in the gravity stability.

This indicates that even the arched type proper might have something more said for it than has been said, especially as there is one successful example of it, the Zola. We have not the least disposition to contend for it, however; on the contrary we believe, with the engineers of the Commission, that the adoption of the pure arched type would be a most unwise and hazardous experiment. We do claim, however, that the case in favor of a straight dam against a *curved* is not made out, and that instead of the straight dam being "far superior in strength, economy and safety," the curved dam has a certain normal advantage in all three of these respects, which may in certain contingencies, like earthquakes, dynamite, etc., become of overmastering importance, and hence is well worth securing, as it may be had for nothing. There will also probably be no question that all other things being equal, the curved dam has the most pleasing appearance, and is hence to be preferred on that ground.

First as to comparative volume and cost: We apprehend that an error has arisen from comparing the two types on the purely theoretical basis of straight or curved *prisms* of equal cross-section throughout; as if the cross-section of the valley were a rectangle. In that case the volume of the curved dam will exceed the straight in the ratio of their respective lengths of crest. But this does not at all conform to the conditions of practice, and leads to deceptive conclusions. All very high

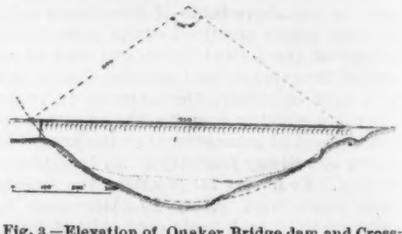


Fig. 3.—Elevation of Quaker Bridge dam and Cross-Section of Valley, showing the degree of its approximation to a circular arc of 600 ft. radius.

dams, from the necessity of the case (they could not otherwise be built at all) are placed in deep and narrow gorges whose usual cross-section approximates to the arc of a circle. Fig. 3 will show how closely the cross-section of the Quaker Bridge valley approximates to an arc of 600 ft. radius having a top chord of 950 ft.

If, now, we further remember that the normal cross section of all high dams approximates closely to a triangle (see Fig. 4) it is apparent geometrically that if the crest be straight, the toe of such a dam in such a valley will be in plan the arc of a circle of such radius *as to give a middle ordinate equal to the bottom width of the dam* and that by laying out the crest in a curve of this same radius the toe of the dam becomes straight. In the Quaker Bridge dam this radius is about 700 ft. In the San Mateo it is about 637 ft. It must

Statue to the memory of Quauhtemoc, last of the Aztec Emperors
Paseo de la Reforma, Mexico.

always be comparatively short on any favorable site for a high dam.

Figs. 5 and 6 show in outline the general nature of two such dams, and from them it will be apparent that the true comparison at Quaker Bridge, and all like sites, is not between a curved dam and a straight, *but between a dam with straight crest and curved toe and a dam with curved crest and straight toe*, THE VOLUME AND STABILITY AS A GRAVITY DAM BEING ALIKE IN EACH CASE.

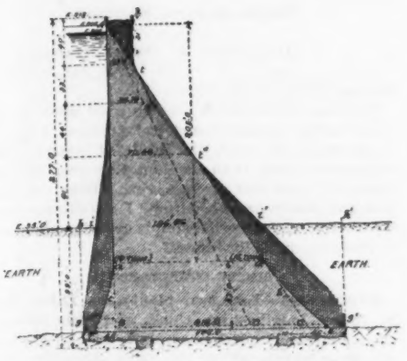


Fig. 4.—Theoretical Sectionof Gravity Dam.

The volumes are the same because the sections at all points, *M A B*, are alike,* the length of the solid between parallel end sections the same, and the volume of each exactly given by the prism oidal formula. The stability is the same because the areas of any sections *M A B* at like distance from the center are equal and similar. Figs. 8 and 9

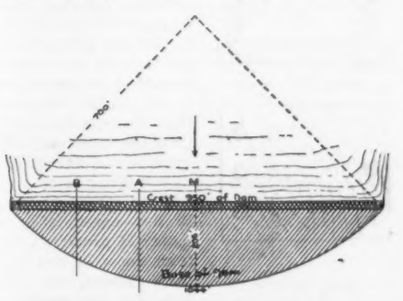


Fig. 5.—"Straight" Dam (with straight crest and curved toe) across the Quaker Bridge valley, assuming its cross-section to be the arc of a circle.

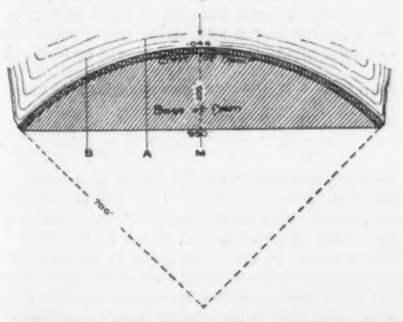


Fig. 6.—"Curved" Dam (with curved crest and straight toe) across the same valley, *and of the same cubic volume as the "Straight" Dam.*

will help to make the equality of volume clearer.

Volume and strength as a gravity dam being EQUAL, what are the other comparative advantages of the form Fig. 5 or Fig 6? The sole advantage which we perceive for the straight type is a very trifling one in first cost, viz., the *difference* in the cost per cubic yard of the crest and lower masonry for the *difference* in the length of the crests. On the other hand there are several advantages secured by the curved form which seem to us of no slight importance.

In the first place, the high central part of the dam is moved up-stream 216 ft., more or less, leaving the ends in the same places. In most cases (we are not advised how it is at

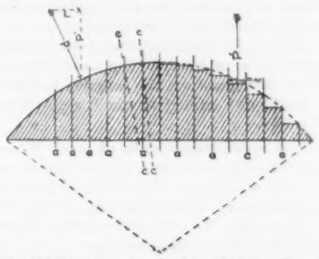
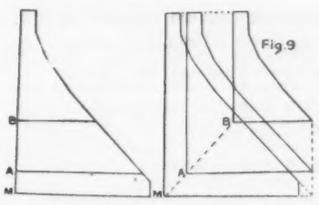


Fig. 7.—Illustrating the Action of Forces in a Gravity Dam with Curved Face.



Figs. 8 and 9.—Projection on a Vertical Plane of the Sections. *M A B*, Fig. 5 and 6.

Quaker Bridge) this would result in taking several feet off the base of the highest part of the dam, from the bed rock lying higher. Every foot off the base of the Quaker Bridge dam saves some 5,500 cu. yds. of masonry out of nearly 600,000. From topographical reasons the longitudinal slope of the bed rock is apt to be particularly great in such contracted necks.

In the second place there is from the beginning a kind of arch action set up (see Fig. 7) which we admit does not in the least affect or increase the normal stability, which is purely from gravity, but which it appears to us will have a highly desirable tendency to close all cracks, eliminate effects of unequal settlement, consolidate the mass transversely (which, as Chief Engineer CHURCH well points out it is very difficult to do without the aid of pressure,) and so prepare the mass to act as a true arch in certain possible contingencies like an earthquake or dynamite when gravity alone would fail, as well as improve its effectiveness under normal conditions.

Our view of the strains set up is this: Conceive the mass to be divided up into layers of, say, one foot each by the parallel lines *a a*, Fig. 7. The water pressure *P*, on the front of any one of these layers is, of course, normal to to the oblique face, and greater than that due to a width of one foot in proportion to the increase of face due to such obliquity. But this normal pressure *P*, resolves itself into two components; a force *P'*, perpendicular to the chord line, which is that due to a width of one foot on a straight face, and a lateral force *L*, throwing the entire face of the dam into compression. This can be seen more clearly (if necessary) by imagining each of these laminæ to be independent solids, with a rectangular front face, as shown at the right of Fig. 7. By arranging these laminæ with their fronts in a right line we have a straight dam, with no lateral force tending to bind them together; by arranging them to fit the arc of a circle, the pressures *L* and *P'*, act directly, without resolution of the forces; the force *P'*, being the same in magnitude, direction and effect as in a straight dam; the force *L*, being an additional and independent lateral force.

It appears to us that a dam made up of such laminæ would have a much better chance of effectual stability by having this lateral pressure to hold them together than if their up-stream faces were set in a line and there were no such pressure. If so, the curved face and straight back is preferable to the so called "straight" type (although it is only straight on one face) even under normal conditions.

Additional strains are set up within the mass; that is true; but strains of such nature that each cube of rock in the dam is subjected to pressure on *all six* of its faces instead of that on four faces only resulting from the gravity action of the dam. Is not this conducive to stability, both theoretically and practically? We take it to be beyond dispute that it is. A block of stone in a testing machine will assuredly sustain more strain if subjected to pressure on all six faces than if pressed on only two or four faces.

What becomes of these lateral strains *L*? Beginning at the bottom course, they are taken up by the friction of the stone on its base, producing only a certain elastic compression. As we rise higher there is more and more of this elastic action, until finally, long before we reach the top of the dam, it is probable that these lateral strains will to a considerable extent, be transmitted as an arch thrust to the abutment, instead of merely reacting against and destroying each other within the mass. To the extent that this action may take place, however much or little it may be, the normal gravity stability will be reinforced, although that is a small matter.

It is to be remembered that the "abutment" is not vertical, but that the span of the "arch" is very much less at the bottom, where the pressure is greatest. If the thrust is not great enough to be transmitted to the natural rock abutment, it will be transmitted to some part of the constructed masonry acting as an abutment. The aggregate amount of the lateral pressure is very considerable, being that due to a surface equal to the maximum cross-section of the dam. Its effect will be simply to produce initial compressive strains throughout the mass, analogous to those which gravity produces in an ordinary arch, so that it is *ready* to act as a true arch in case the gravity stability alone should at any time prove inadequate, in certain contingencies although these lateral pressures do not add in the least to the theoretical stability under normal conditions. Remembering that the stability due to gravity always continues unchanged, even if arch action is from any exceptional cause set up likewise, we shall endeavor to show next week that it is well worth while to provide for such exceptional causes when it can be done at no appreciable cost and with a certain appreciable advantage even under normal conditions.

*We neglect as too small for consideration a trifling difference in favor of the straight dam, due to the fact that the roadway must be of the same width *normal to the curve*, giving a somewhat greater width on sections normal to the chord-line.

The Merced Irrigation Canal.

The Merced Canal was opened on Feb. 1, after 5 years work and the expenditure of $1,500,000. This canal is the largest irrigation work in this country and will water 465 sq. miles of the large county of Merced, California, in the heart of the San Joaquin valley. Work was commenced in Feb. 1883 by C. H. HUFFMAN with the assistance of CHARLES CROCKER, the millionaire Vice-President of the Southern Pacific R. R.

The present canal is 27 miles long, 70 ft. wide in the bottom, 100 ft. at the water surface and 10 ft. deep The fall is 1 ft. per mile. It passes through two tunnels; one 4400 ft. long, by 23 ft. wide by 14 ft. high; the other 3000 ft. long with similar dimensions. The first tunnel has a fall of 14 ft. and the second of 10 ft. to the mile.

The canal approaches within 5 miles of Merced to a low valley which has been converted into a huge reservoir. This latter work required the building of a dam 4,000 ft. long, made of earth and gravel. This dam is 275 ft. wide at the base 20 ft. at the top and 54 ft. high. When full this reservoir will cover 640 acres to an average depth of 30 ft.; or, it holds enough water to irrigate 30,000 acres to a depth of 1 ft. The reservoir is 90 ft. above the level of the town of Merced and will supply that place with water through a 16-in. pipe.

Across the Merced river is another dam of timber crib-work filled with stone. This dam, which is 2 miles below Merced Falls, raises the water in the river 10 ft. A timber headgate with a 90 ft. opening lets out the water from the dam when required for use below.

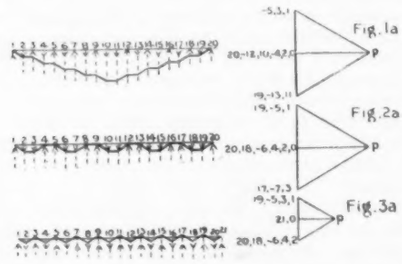
Engineers estimate that this canal will irrigate 300,000 acres of land, through a system of ditches and head-gates, built by the company, with smaller ditches to be built by the consumers. The general plan of the company proposes to extend the canal 25 miles beyond Merced, where another 300,000 acres would be irrigated. The estimated cost of the extension is about $800,000. The canal company owns about 50,000 acres of the finest land along the canal, and controls about 10,000 acres more. It proposes to develop this land, and cut it up into colony lots of any size to suit purchasers, and sell it with a perpetual water-right at from $60 to $75 per acre. To those owning land the perpetual water-right is sold at $10 per acre.

We regret that while the daily press has devoted a column or more to the financial prospects of this scheme and the names and purposes of its financial backers, the name of the engineer of this greatest irrigation work in the country is not once mentioned. While the omission is only too common, it is very marked in this case where particular stress is laid upon the engineering difficulties met and overcome.

CORRESPONDENCE.

Fiber Strain in Pins.

In our last issue the Figs. 1*a*, 2*a*, 3*a*, were inadvertently omitted from the letter of Prof. JOHNSON, on the above named subject, owing to the fact of having two illustrated letters by the same author in



type at one time, though on very different subjects. As the question at issue is an important one we now give the missing diagrams. ED. ENG. NEWS.

"Division" and "Resident" Engineers.

Minneapolis, Sault Ste. Marie & Atlantic Ry, Chief Engineer's Office.

MINNEAPOLIS, Minn., Jan. 24, 1888.

EDITOR ENGINEERING NEWS:

In your issue of the 21st. inst., I note with some interest your editorial on titles of "Division," "Resident" and "Assistant" Engineer, and hope the committee may report in accordance with your suggestions. The views you express have been my own for many years. I enclose a copy of my memoranda for the instruction of engineers as revised and reissued a year ago, in which the rank of engineer is defined. The organization as outlined has given good results in the construction, during the season of 1887, of nearly 430 miles of railway, giving ample employment for seven Division Engineers. My office has never received a report directly from a Resident Engineer. Had I as much on hand for another year, I would appoint an Assistant Chief Engineer to share with me the general work.

I think your remarks are timely as to the title of "Consulting Engineer." I appointed a very competent engineer—residing in an adjoining city—as Consulting Engineer to assist me in the work of iron bridges and roofs, etc., and did so knowing him more competent than myself to proportion details of such work. Whenever a railway company proposes to appoint for me a "Consulting Engineer," or a "Superintendent of Construction," I am ready to step down and out. It would be introducing the absurdity of a "joker" to rank the right bower, and the latter's day of usefulness would be past.

I am not writing this for publication necessarily, but to say Amen to your discourse on a matter which may not be of such overwhelming importance as the discussion of Prof. DUBOIS and Mr. JOHNSON, but which is a question, the sensible settlement of which would put an end to much annoying confusion of terms.

I enclose some memoranda of work done by us the past season from which, if you choose, you can make a brief statement. Considering the character of the country—an almost trackless forest of heavy timber from the Wisconsin river, east 278 miles—we think our record unsurpassed.

Very truly yours, W. W. RICH,
Chief Engineer.

[The memorandum enclosed shows:

Line constructed prior to Jan. 1, 1887	141	Miles.
" built in 1887	359½	"
Cu. yds. of earth and rock, 1887	7,502,805	
" per mile	20,870	"
M. ft. B. M. timber	13,510	
Lin. ft. piling driven	631,794	
Cu. yds. bridge masonry	1,050	
" culvert "	3,123	

24 spans Howe truss bridges.
Shops erected at Minneapolis $250,000
1000 ft. dock (20 to 24 ft. water) at Gladstone.
Line opened entire length, Jan. 2, 1888.
Max. Tangent gradient, Minneapolis to Gladstone ..... 42 ft. per M.
Max. Tangent gradient, Gladstone to Sault Ste. Marie ..... 32 "
Curves 3° and less for the most part: a few 4° curves, and four 5° curves. Curves flattened at ends by compounding.
Greatest elevation above Lake Michigan, 1,112 ft.
Employed at midsummer, 7,000 men and 1,100 teams.
Rails, 60 lbs. per. yd.; Samson angle bars, suspended joints; 2,816 to 3,000 ties per mile; stand-pipe water service; freight cars, 50,000 lbs. capacity; engines, 17×24 cylinders, 55,000 lbs. on 4 drivers.
Consolidation engines to be put on for through freight service.

The engineer force is divided into:

Division Engineers, in charge of all work on 50 to 75 miles of line.

Locating Engineers, ranking with division engineers, and reporting also to the chief.

Resident Engineers, in charge of 10 or 12 miles.

Assistant Engineers, in charge of bridges, buildings, docks, yards and other special work, reporting to the division or chief engineer as directed.

The instructions occupy seven legal cap pages in print, and contain various excellent points, which are not always so definitely specified, and which we may notice more fully later.—ED. ENG. NEWS]

A Contradiction.

LOUISVILLE, Ky., Jan. 26, 1888.

EDITOR ENGINEERING NEWS:

I find that your journal of Jan. 21, 1888, had a letter from L. S. JONES president of a new projected line called the Omaha, Lincoln & South Western R. R., and quoting me as their Chief Engineer. This does me an injustice, and I beg you to contradict it emphatically. I have nothing whatever to do with the project, and I cannot understand by what authority Mr. JONES used my name in connection with the project. Will you kindly say in your next issue that I am not Chief Engineer of the O. L. & S. W. R. R., that I never intend to be, and while open to railroad engagements, I propose to be consulted before being used.

Yours respectfully, F. de FUNIAK.

[There can be no doubt that Mr. de FUNIAK is the best authority obtainable on matters concerning his own affairs, and though the president of a railroad company certainly ought to know the name of his own Chief Engineer, it is plain that in this case at least, the head of the O. L. & S. W. R. R. was in error. Those who are acquainted with the evanescent character of Kansas thousand mile railway projects, will understand why Mr. de FUNIAK objects to the use of his name in connection with one of them.—ED. ENG. NEWS.]

Unsymmetrical Sections.

Department of Civil Engineering,
ST. LOUIS, Jan. 9, 1888.

EDITOR ENGINEERING NEWS:

Will you kindly allow me one word more on the vexed subject of unsymmetrical sections. I believe I can pour oil upon the troubled waters. The confusion arises from confounding two distinct kinds of loads and stresses, viz.: direct compression and simple cross-bending. I will discuss them separately, and prescribe simple experiments which anyone can make for himself.

SIMPLE COMPRESSION.

Experiment.—Take two planks, say 12 ins. wide by 15 ins. long by 2 ins. thick, and place between them four steel springs, carefully ground down to the same length, all of the same strength. Put three springs on one side and one on the other, as shown in Fig. 1. Let the distance between the axial line of the springs be 12 ins. Now what is the position of a load *which will compress all the springs equally?*

The springs correspond to the fibers of an unsymmetrical cross-section, subjected to direct compression. In this sense, if the springs are of equal strength, they correspond to *equal areas* in a cross-section. Let this elementary area be represented by *a*. Let *n n'* be a line passing through the center of gravity of the system, and x_1 and x_2, the distances of this line from the one, and from the three springs respectively. Evidently, $a\ x_1 = 3\ a\ x_2$; or $x_1 = 3x_2$.

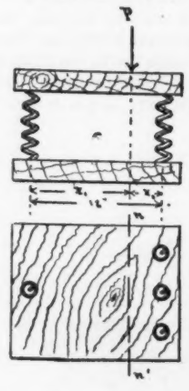


Fig. 1.

If the springs are placed 12 ins. apart, then the center of gravity is 3 ins. from the axial line of the three springs, and 9 ins. from the one spring. It almost goes without saying, too, that if a load *P*, is centered on this line on the axial line of the plank, it will compress all the springs equally, and the planks will remain parallel to each other. Here the *moments* of the stresses in the springs, on the two sides of the load line, are equal to each other.

That is, if $\frac{P}{4}$ be the load in each spring, we have

$$\frac{P}{4} x_1 = \frac{3P}{4} x_2, \text{ since } x_1 = 4\ x_2$$

And this is exactly what Mr. THOS. H. JOHNSON has asserted. The *moments* in this case are, of necessity, equal. But we see that the *line of loads* is also the *center of gravity* line, which he has from the first denied. In this case there is no equality of stresses about the neutral axis, and such equality has never been asserted by anyone in this discussion. It is only in the case of simple cross-bending that the *stresses* on the two sides of the neutral axis are equal, a simple experimental proof of which will now be described.

SIMPLE CROSS-BENDING.

Experiment.—Take two pieces of 6 ins. × 15 ins. timber, shaped as shown in Fig. 2, and support them by two boards, under their centers of gravity as shown. Let one of these boards be held rigid, and the other pivoted at the floor. Attach the timbers together by four springs, one at the top, three at the bottom, the upper one to resist tension, and the lower ones to resist compression. Let the distance between the axial lines of the springs be 12 ins. Attach weights, *P*, to the outer levels of the sticks,

thus introducing a uniform bending moment on the sticks between the two points of support. This is now a case of *simple cross-bending*, and the strains caused are tension in the upper fibers and compression in the lower fibers of this part of the beam. These stresses can be resisted wholly by the springs. These springs now serve to take up and transmit this bending moment from one stick to the other, and they take the place of an unsymmetrical connecting section. If the loads P are equal and symmetrically placed, there will be no shearing action between the two supports. Now what will occur?

Mr. THOS. H. JOHNSON says the stress in the upper

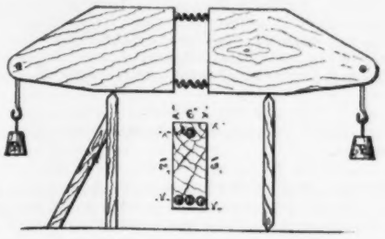


Fig. 2.

spring is *not* equal to the sum of the stresses in the lower springs, but that the *moments* of these stresses about the neutral axis are equal, which neutral axis is not at the center of gravity of the resisting fibers (springs,) but that the position of this axis is, of necessity, and proved to be experimentally, so placed as to *make* these moments equal.

On the other hand the "text books" and the "schools" all say that the stress in the upper spring is exactly equal to the *sum* of the stresses in the lower springs, that the neutral axis traverses the center of gravity of the resisting fibers (springs), and that therefore the *moments* of these stresses about this axis are *not* equal as a matter of fact, neither is there any reason in the world why they should be equal.

The stress in one of these springs will be shown by the amount of its distortion, (within its elastic limits), so we have but to measure the change in the width of the space on the axial lines of the upper and lower springs to determine the stresses in the corresponding springs. If this be done it will be found that the *upper space line has increased just three times as much as the lower one has diminished*, and hence the stress in this spring is just three times as much as in *one* of the lower springs, or it is equal to the sum of the lower spring stresses. Furthermore, it will be found that the space has remained constant in width on a line just 3 ins. above the line of the lower springs. This is therefore the position of the *neutral axis*, or of the fiber which has neither been elongated nor compressed.

Now what would Mr. JOHNSON'S theory lead to? If x_1 = dist. from neut. axis to upper spring,

x_2 = " " " to lower springs. Then the *stresses* will vary directly as these distances, or

stress on upper spring $= a\,x_1$

" " each lower spring $= a\,x_2$

and the *moments* of these stresses are:

moment of stress on upper spring $= a\,x_1^2$

" " stress on each lower spring $= a\,x_2^2$

and if these moments are equal, then $a\,x_1^2 = 3\,a\,x_2^2$, or $x_1^2 = 3\,x_2^2$ or $x_1 = x_2\sqrt{3} = 1.73\,x_2$ or $2.73\,x_2 = 12$ ins. whence $x_2 = 4.4$ ins. That is to say, if the *moments* of these stresses are equal, the neutral axis is 4.4 ins. above the axial line of the lower springs instead of *three* inches, according to the "books." This would also involve a stretch of the upper spring of but 1.73 that of the compression in the lower springs. Now it would not require any great refinement of observation to note whether the line of no variation of span was 3 or 4.4 ins. from a certain point, or whether the upper spring stretched 1.73 or 3 times as much as the lower ones shortened.

If the above experiments be made with anything like scientific care, and the upper spring does not distort three times as much as the lower ones, and the line of no change is not 3 ins. above the axial line of the lower springs, then the whole science of statics is false, and to Mr. JOHNSON belongs the distinguished honor of proclaiming that fact to the world. But before he challenges further the sanity of all previous thinkers on this subject (for these misguided people insist that their statements have all the absoluteness of geometry), he should try so simple an experiment as the above, and so obtain at least one fact with which he indeed *might* overthrow the whole structure of statics. For in this case it *seems to us* just as impossible that the *stresses* on the two sides of the neutral axis should be unequal, as that two and two should be five.

There is a necessity, also, that there should be an equality of moments somewhere, but in this matter *it seems to us* Mr. JOHNSON is insisting that the parts of a whole are of necessity equal to each other instead of that more familiar way of putting it—the whole is equal to the sum of all its parts. The whole science of mathematics seems to be endangered, therefore, as well as that of statics.

The principle concerning moments is that the sum of the moments of all the resisting forces on any section, about any point, shall equal the sum of the moments of all the external forces on either side of that section about the same point. Now the total moment of resistance here is made up of the tension in the upper spring into its arm x_1 *plus* the compression in all the lower springs into their common arm x_2. The sum of these two parts makes a *whole*, which is to be equal to another whole, made up in this case of the couple formed by the load P and its equal supporting force on that side, into the arm, which is the distance between them. But Mr. JOHNSON says nothing about the equality between those two *wholes*, but insists that there is some mathematical necessity why the two *parts* which make up the first whole should be equal to *each other*. A new axiom in mathematics is it not?

Most of the above points were fully covered in Prof. DUBOIS' article of Dec. 17, but he used the forms of the calculus which do not seem to carry conviction with them to all minds. The calculus is necessary, however, to a general treatment of the question, and a person who can use that language is never satisfied to use the simpler form of special cases with their limited range and narrow conclusions.

The reason why experiments seem to indicate that in direct compression the neutral axis (or rather the line of loading for equal stresses—since there is no *neutral* axis,) seems not to traverse the center of gravity, in unsymmetrical sections, is because the elastic limit (which MARSHALL has now shown is coincident with ultimate strength with members in comparison,) is different in the different members of a built beam, or because of the assembling of the parts, the riveting, the different relations on the two sides of area to structural strength, etc. That is these tests are for *failure* and not tests within the elastic limits. There would still be an *apparent* failure in the theory within this limit, if the modulus of elasticity of the parts on the two sides of the neutral axis were different. Then one side would be compressed more than the other for the same unit stresses, and the inference would be that the stresses there were greater.

As to the PENCOYD experiments on unsymmetrical sections of iron beams, *tested to failure*, it should not be expected that the theory of uniformly varying stress would hold good. When the extreme fibers on the heavy side have reached their elastic limit, those on the opposite side are still far within that limit. A greater load will now cause the stresses in those fibers on the heavy side to pass their elastic limit, that is the increase of distortion here is *greater* than the increase of stress, and a section, which had been originally a plane, and which *remained* a plane up to the elastic limit, is now no longer a plane, and the law fails which puts the neutral axis at the center of gravity of the section. The result on the neutral axis is to move it nearer the smaller side, and so it continues to move up to the point of rupture. That *at* rupture it should be about where the moments of inertia on the two sides are equal is a mere accident, and not at all surprising. But *even at rupture*, it is absolutely necessary that the sum of the compression stresses should exactly equal the sum of the tensile stresses, in other words their algebraic sum must be zero, since they are at all times in equilibrium with the sum of the longitudinal components of the external forces on one side of the section, which components are always zero in simple cross bending.

If I have not succeeded in making it clear to you, Mr. Editor, that there is at least *some* reason in our position, or in convincing the gentleman who started this discussion that whatever his facts may be they cannot be accounted for by his new theories, I still trust that I have cleared away some of the mists which seemed to be gathering about this subject in the minds of many of your readers.

J. B. JOHNSON.

[The space devoted to this subject is assuming very unsymmetrical proportions in our paper when compared with other matter, and we feel compelled to call a halt. This step is especially necessary when the yet unpublished material on this dispute is considered.—ED. ENG. NEWS.]

The Nicaragua Canal Survey.

SALTOS DE ELVIRA, NICARAGUA, Jan. 2, 1888.

EDITOR ENGINEERING NEWS:

I will send my new year greeting in the form of a short letter to let you know something of the doings of the canal expedition since leaving New York.

A little over a month ago we steamed out from New York accompanied by the best wishes of personal friends, and the promoters of the canal enterprise. So far as health is concerned, their hopes and wishes have been fully realized. We reached Greytown on the 9th of December, and came to anchor about six miles from the town, outside the bar, and were three days in transferring our outfit to the wharf with a steam lighter.

The town formerly had a good harbor, but owing to a change in the mouth of the San Juan river, a bar has formed that only allows vessels of light draught to pass. It would appear from an examination of the location that there would be no serious difficulty in restoring the harbor.

Greytown is at present a village of about 300 inhabitants, mostly natives, though the business is mostly in the hands of foreigners. We were fortunate in meeting our agreeable Consul and Vice Consul, Messrs. BROWN and SCOTT. The town is a typical tropical village, with one story wooden buildings, built more for the purpose of securing good ventilation than for architectural effect. There are several stores where almost anything needed in a civilized country can be obtained at reasonable rates. The town is situated on a low sandy plain, and nearly surrounded by the river and lagoons, but has a good reputation for healthfulness. Since the advent of the surveying expedition town lots are booming and there are many prospective millionaires.

After spending the necessary time in separating the supplies and outfits for the various parties, we steamed out from the wharf, just after daylight of a most lovely morning, to make the journey up the San Juan river and establish headquarters on the San Francisco Island, just below where the San Francisco river empties into the San Juan. From here the various parties separated, each going to their especial location.

To one unaccustomed to tropical vegetation, and I think to any one, the trip up the San Juan on such a day as we were favored with is most enjoyable. The river has a width varying I should judge, from about a quarter to half a mile and in the lower portion a good depth of water. The vegetation along the river is something wonderful, and the many brilliantly colored birds which inhabit it no less interesting. Troops of various colored monkeys could be seen trooping among the trees or hurrying from tree to tree to place themselves out of reach of imaginary danger. Ever and anon a huge alligator would be seen lazily sunning himself on a mud bank, but in general he soon became animated enough, for rifles were brought into requisition, and altogether it was not a good day for alligators.

The banks of the lower San Juan are low and flat, but before reaching San Francisco Island some considerable hills are seen. There are a few fruit plantations on this point of the river, where a small supply of most delicious oranges and other tropical fruits may be obtained. They are mostly owned by natives who live in sheds without sides and a roof thatched with palm leaves. The costume of the younger portion of the family is that provided by dame Nature. The ladies wear apparently one garment cut ex-

tremely *decollette*, or as one member of the party very aptly put it "lo and behold" dresses.

The whole eastern slope of Nicaragua is almost an uninhabited wilderness, which might be made a magnificent fruit growing region. It also appears to have an almost inexhaustible supply of valuable timber, but as all the timber is so heavy that it sinks in water, it requires some better means of conveyance than is now available to make it accessable.

It has taken me nearly two weeks to carry my party, together with their outfit and supplies, from headquarters to my present camp with three steel canoes, while the distance across country, as the crow flies, is only about five miles. As to the distance by water, I can only say it seems interminable, and the number of logs to be cleared out almost infinite. However, we are here on the divide between the waters of the San Francisco river on the west, and the Diseado on the east, and have begun work. I have not yet been over the divide, and can therefore give no more engineering information than is contained in the report of the" Nicaragua Surveying Party of 1885," by Civil Engineer A. G. MENOCAL, U. S. A.

This is the heaviest work on the entire line and presents some interesting problems, which I shall hope to present to your readers at some future time.

There are five surveying parties in the field and one boring party. As you have undoubtedly obtained the personnel of the expedition from their New York office I will not give it.

Very truly, FRANK P. DAVIS.

PERSONAL.

PEYTON RANDOLPH has been appointed General Manager of the Richmond & Danville Railroad system to succeed Mr. E. B. THOMAS who has resigned.

THOMAS L. MOORE, late Assistant Engineer to the Aqueduct Commission, has been appointed to a similar position by Gen. NEWTON in the bureau of Sewers, Department of Public Works, New York City.

CHARLES BLACKWELL, formerly of the Union Pacific R. R., has been appointed Superintendent of Motive Power of the Georgia Central R. R., with headquarters at Savannah, Ga.

Major WILLIAM LUDLOW, U. S. Eng'rs. has been relieved from his position as a Member of the Board of Commissioners of Washington, D. C. In his letter announcing the appointment of Major CHARLES W. RAYMOND to succeed Major LUDLOW, the President expresses his confidence in the ability and certifies to the efficiency in the performance of duty of the late Engineer Commissioner.

SAMUEL G. ARTINGSTALL, lately removed from his position as Chief Engineer of Chicago, for reasons stated in our last issue, has asked for reconsideration of his dismissal by Commissioner SWIFT. He says the "mischievous" letter was thoughtlessly given out of kindness to a discharged employé and was not intended to reflect upon the administration, and that he was further, as much surprised as any one at the misuse of this letter. Mr. ARTINGSTALL says that sickness and death in his family have much distracted his attention from official duties lately. He also suggests the appointment of a practical mechanical engineer to be put in charge of the pumping works, etc., of the city. It is said that the Mayor and Commissioner SWIFT will consider the matter and will probably divide the former duties of the office and put Mr. ARTINGSTALL in charge of the bridges, and similar engineering construction.

The Baldwinsville Centrifugal Pump Works, Syracuse, N. Y., has recently shipped to the Propellor Tow Boat Company, Savannah, Ga., one of its No. 8 centrifugal wrecking pumps complete with suction pipes etc., capacity 5,000 galls. per minute. Also shipped two No. 15 pumps, capacity 16,000 galls. each per minute to the Milwaukee Shipyard Co., Milwaukee, Wis., to be used in draining the new dry dock, also a No 8 sand pump to W. C. JONES, Greenville, Pa., with capacity of 75 to 100 cu. yds. per hour of sand.

The firm has also in course of construction another No. 8 sand pump for parties at Wichita, Kan., and six wrecking pumps for a Chicago house, to be used on the lake.

STORIES are being revived in California of GASSEY THOMPSON, a Colorado miner, who was well known throughout the West in earlier days. He contracted one winter to run a 3,000-foot tunnel at $10 a foot for a rich company. He timbered it nicely and got his pay, and in the spring the company found that they had nothing but a skeleton framework. THOMPSON had run the tunnel along the side of the gulch in the snow.

STATISTICS OF NEW WATER-WORKS CONSTRUCTION.

(*Specially Communicated.*)

(CONTINUED FROM PAGE 68).

Dover, N. J.—The works were commenced May 11, 1887, and accepted Jan. 9, 1888; they were designed by ISAAC S. CASSIN, who was also Constructing Engineer. The supply is by gravity. The franchise is for 10 years and the hydrant rental is $40 per annum. The franchise is owned by the Dover Water Co.; President, ARCHER N. MARTIN; Secretary, CHARLES E. KIMBALL; Superintendent, PHILIP J. H. BASSETT. The population is estimated at about 4,000.

"Our reservoir, with a capacity of 6,000,000 galls., is situated on an elevation about 1 mile from the town. We receive our water from a system of springs which are connected with reservoir by terra-cotta pipe. To make complete connections with springs and reservoir it took 15,321 ft. of terra cotta pipe. The inflow of water from watershed is 300,000 galls. daily. The iron pipe connecting the reservoir with the business center of the town is 10 ins. diameter. From this point the pipe is reduced in size to 8 ins. and as it reaches the suburbs to 6 and 4 ins. We have laid in all 6¼ miles of iron pipe. At the business center of town the water has a head of 170 ft. or nearly 80 lbs. pressure to the sq. in. The town is supplied with 50 fire hydrants, suitably located, from which the company receives a rental of $40 per hydrant. The work of constructing was given to a contractor, who abandoned the work when about half completed, and the company finished the works.

PHILIP J. H. BASSETT.

Kentville, Nova Scotia.—The works were commenced in 1887 and are nearly completed; they were designed by H. W. FORBES, of Boston, who was Constructing Engineer. The contractor was Wm. Sutherland; the pipe was furnished by Black & Co., of Glasgow; the specials by the Builders' Iron Foundry, Providence, R. I., and the valves by the Chapman Valve Manufacturing Co., of Indian Orchard, Mass. The price for trenching and pipe laying was 25 cts. per ft. The works are owned by the town, which has a population of about 3,000.

Brownwood, Tex.—The works were commenced in the summer of 1886, and accepted in October, 1887; they were designed by M. L. LYNCH, of Temple, Tex. The contract for the entire work was taken by R. D. Wood & Co., of Philadelphia, Pa. Worthington pumps are used. The standpipe is 100 ft. high and 20 ft. diameter. The franchise and works are owned by the city, which has a population of about 5,000. (For further particulars see p. 17).

TO BE CONTINUED.

SOCIETY PROCEEDINGS.

American Society of Civil Engineers.—Regular meeting of Feb. 1. Vice President J. J. R. CROES in the chair and about 30 in attendance. The death was announced of the following members; CHARLES H. FISHER, Lansingburg, N. Y., elected Member July 7, 1869; FREDERICK MERCUR, Wilkesbarre, Pa., elected Member July 20, 1870. FRANK BERESFORD, Cincinnati, O. The paper of the evening was by S. H. CHITTENDEN, Member of the Society, upon the construction of a dam across the Potomac river near Washington, D. C. The water supply of Washington is taken from the Potomac river at a point about 14 miles from the city, above the Great Falls of the Potomac. At this point the river flows in two channels, the water level in the deeper of which was already raised by a masonry dam built when the water supply was first established. It was required to raise the water level above this dam by putting upon it a 15 in. coping, and also to raise the water level in the smaller channel by building a dam across it. This channel was about 500 ft. in width and the water in the deepest portion was about 12 ft. deep with a swift current and rock bottom. On account of the swift current and the seamy and broken character of the bottom, the ordinary form of coffer dam was not attempted. A rubble dam was built part way across the stream and its upper surface was stopped with clay. Just below this a coffer wall 10 ft. thick was built and after much trouble in stopping the leaks in the seamy rock with straw, clay and sedge grass, the enclosure between the rubble dam and the coffer wall was made tight enough so that it could be pumped out and the masonry dam built. The work was carried on from the shore and in sections of no great length, and various delays prolonged the work through three seasons. For draining the coffer centrifugal pumps were used, power being furnished by traction threshing engines, which were highly commended for convenience, economy and effectiveness.

The following candidates were found elected:

FOR MEMBERS:

DANIEL SEYMOUR BRINSMADE, LORENZO RUSSELL CLAFF, FRANK PAUL DAVIS, CLARENCE DELAFIELD, WILLIAM FRANKLIN DENNIS, EDWARD FLAD, EMIL GERBER, GEORGE BLAGDEN HAZLEHURST, ALLEN BOGARDUS HEGEMAN, ALEXANDER JOSEPH SWIFT, ELLIOTT H. WILSON.

FOR JUNIORS:

KAYAJIRO KOBAYASHI, GEORGE E. MOULTHROP, ROBERT RIDGWAY.

Engineers' Club of Philadelphia.—Record of regular meeting, Jan. 21, 1888. President JOSEPH M. WILSON in the chair; 24 members and 1 visitor present. The Secretary presented, for Mr. C. H. OTT, an account of a "Peculiar Case of Transmission of Vibrations and Pulsations through Structures." Annoying, and even serious, vibrations, in this case, were found, by direct experiment, to be occasioned in a building at one end of a solid row 400 ft. long, by the operation of a small engine running a spice grinder in a retail grocery store at the other end of the row. A general discussion of vibrations in structures followed, participated in by a large number of members, and numerous instances were noted. Mr. JOHN T. BOYD described vibrations, in a large office building, that had never been satisfactorily accounted for; Mr. HENRY G. MORRIS, in a large hotel, created by the elevator pumps; Mr. HOWARD MURPHY, the relative effects of the earthquake on different floors of an office building; Mr. F. W. WHITING, where the fourth story of a five-story mill building in Philadelphia, vibrates ¾ in., and a mill building, in Massachusetts, where the vibration is so great as to cause nausea among new employés, and where the water cannot be kept in a fire bucket, yet the building is probably at least ten years old and seems to stand it. Mr. JOSEPH M. WILSON referred to the evil effects of continuous vibrations in structures, and noted, incidentally, a case in his recent practice where large marble blocks had been broken by the freezing of water in the lewis holes; Mr. HOWARD MURPHY referred to the vibration in the large Scotch stacks, and Mr. HENRY G. MORRIS noted the case of a stack 125 ft. high, where the vibration was 1¼ ins. Messrs. SEAMAN, HAUPT, CLEEMANN, BROWN and REDWAY took part in the discussion.

Prof. L. M. HAUPT submitted a few extracts from the report of the Chief of Engineers with reference to the "Theoretical Operation of Submerged Jetties," and made some comments thereon to show why the system had apparently not proved more successful. The initial report on the project for Charleston, for 1878, p. 563, *et seq.*, states:

1. "The north jetty will reduce the half-tide area of the water way from its present area of 78,880 sq. ft. to 41,593 sq. ft." (47 per cent.)

2. "The south jetty half-tide water way will be reduced from its present area of 201,365 sq. ft. to an area of 94,684 sq. ft." (53 per cent.)

3. "In the gap" (between the jetties), "where alone erosion can take place, the present mean half-tide water way is 29,572 sq. ft., and the mean low tide area, 22,840 sq. ft."

4. "After the jetties shall have received their maximum scour, aided by dredging or other artificial appliances wherever clay beds are encountered, and the equilibrium of flow is resumed, the original average slope ($S = 0.000,002,498$) will be restored."

5. "The aggregate average discharge per second before the jetties were built will also be restored."

On these assertions the hydraulic radius between the jetties is computed to "be 42.22 ft. at mean half-tide, or 39.71 ft. at mean low water. * * * * * *

6. "In the new channel between the jetty heads, where the hydraulic radius is 39.71, it may be expected that the area of depths of more than 24 ft. will constitute a very large proportion of the total area of the gap, and that maximum depths of 75 ft. and upwards would be maintained in mid channel."

7. The sectional area of the gorge profile between Cummings Point, and Sullivan's Island is, "Mean ebb-tide area 176,600."

From Extracts Nos. 4 and 5 it would appear that there will result the same surface slope (S) and the same aggregate average discharge (Q) after the construction of the jetties as before. In other words, the jetties do not affect the slope or aggregate volume. In the CHEZY formula for the velocity of discharge, which was used

in this case, we have $V = C\sqrt{RS}$, and, solving with reference to S, it becomes $S = \frac{V^2}{C^2 R}$, but R is equal to the area A divided by the wetted perimeter (p), which latter may be regarded as a constant. Hence, if S is constant, or remains the same as before, $\frac{V^2}{R}$ must be a constant ratio, or V^2 must vary as R varies; but R, being a function of A, is reduced nearly one-half by construction, hence V^2 must also be reduced nearly one-half. As the *quantity* is a product of the *area* into the *velocity*, and as both of these factors are reduced by the construction of the jetties, it follows that the "aggregate average discharge" cannot be the same as before. Moreover, since the jetties are about half done we should expect a maximum depth between them of the half of 75 ft., or 37½ ft., instead of 13, if the assertion in 4 and 5 be correct. As a matter of fact, a contract was made for dredging between the jetties, for an amount not to exceed 200,000 cu. yds., at 30 cts. This contract was terminated Dec. 31, 1885, after removing 85,519 cu. yds. When it is considered that the plans for Sabine Pass, Galveston, Port Cavallo, Aransas Pass and other points, are all based upon this theory of submerged jetties, and that they are estimated to cost between eight and ten millions, it would seem better to make a practical demonstration of their success at some one entrance before attempting so extended an application.

Mr. A. MARICHAL presented a mathematical discussion of the "Theory of Curved Dams" for the Reference Book.

Mr. F. W. WHITING noted a case in hydraulics, where attempt had been made to bring water in a pipe across an embankment, which had been unsuccessful until an opening was made at a point in the pipe line, and a small pipe extended therefrom to the level of the source.

Mr. HOWARD MURPHY suggested that the trouble had probably been caused because the hydraulic gradient had not been considered in the original location of the main pipe.

HOWARD MURPHY, *Sec'y. & Treas.*

Illinois Society of Engineers and Surveyors. At the late annual meeting of this Society, at Springfield, Ill., the following officers were elected for the present year:—President, C. G. ELLIOTT; Vice-President, D. W. MEAD; Treasurer, A. N. TALBOTT; Secretary, S. A. BULLARD, Springfield, Ill. In addition to the usual routine business and committee reports, a paper on "Hygienic Engineering and Architecture" was read by Dr. G. N. KREIDER, late of the State Board of Health. The next meeting will be held in Bloomington, Ill.

Montana Society of Civil Engineers.—The first annual meeting of the Society was held at Helena, Mont., Jan. 21. The following officers were elected: President, GEO. K. REEDER, Helena; 1st Vice-President, ELLIOTT H. WILSON, Butte; 2nd Vice-President, E. H. BECKLER, Helena; Secretary and Librarian, J. S. KEEBL, Helena; Treasurer, JNO. W. WADE, Helena; Trustee for 3 years, W. W. De LACY, Helena. The meeting adjourned to meet in Helena, at the office of J. J. DONAVAN, Chief Engineer, Northern Pacific branch lines in Montana, at 7.30 p. m. Feb. 18. The following resolution was unanimously adopted:

HELENA, Mont., Jan. 21.

To the Honorable Society of Engineers.

Gentlemen: The undersigned, your committee appointed to draft resolutions of respect to Col. J. T. DODGE, beg leave to submit the following for your consideration.

Whereas, From the necessity of attention to personal affairs, and by reason of over-exertion in advancing the interests of his employers, our associate in engineering and president of our society, J. T. DODGE, has deemed it due to himself to turn from the active pursuit of his profession and sever the agreeable relations he has so long held in our midst, and desiring as a body to express our appreciation of his character, for his valuable services in organizing our society and encouraging young engineers to take an active interest therein while serving as its president; be it:

Resolved, That we recognize in him attainments found in few of the profession which has called forth his life's best energies, and that we regard his engineering achievements here and elsewhere as monuments of which he may justly be proud.

Resolved, That we regard his life and especially his career in Montana as calculated to elevate our profession and to fully demonstrate that great possibilities lie within grasp of those who will emulate the example which his professional life has furnished us.

Resolved, That while deeply regretting his departure from our midst, and the severance of his connection with our society as its honored head, we assure him of our grateful remembrance and best wishes in whatever field his energies may be engaged. E. H. BECKLER, J. W. WADE, GEO. K. REEDER.

The routine business was followed by a banquet, at which the following toasts were proposed: "The Montana Society of Civil Engineers," responded to by E. H. WILSON; "The Press," Hon. W. KENNEDY; "The brave men who Locate Railroads at 50° below zero," L. B. LOTHROP. "Relation of Civil to Army Engineers on Public Improvements," H. B. DAVIS; "The Engineer and his Achievements," E. H. BECKLER; "The West and its Future," J. S. KEEBL; "Are Engineering and Matrimony Incompatible," A. S. HOVEY; "Our Railroads," J. J. DONOVAN; "The Early Days of Engineering," Col. De LACY.

Western Society of Engineers.—The annual meeting (the 243rd of the society) was held Jan. 3, at the Tremont House, Chicago; D. J. WHITTEMORE, President *pro tem.* The report of the secretary was as follows:

During the past year eleven meetings have been held and eleven written papers have been presented. Sixteen members have been added to the Society, making a total of 196 now on the rolls. The receipts have been $760, which, added to the amount on hand at the beginning of the year, $70.05, makes a total of $830.05. The amount paid out is $791.55, and unpaid bills amount to $86, showing that the Society is indebted for $47.60. More than this amount however, can probably be collected from the 40 members whose dues are now delinquent. In the Annual Report of the Secretary for the year 1886 it was stated that, with the annual dues at $5 and $6, the Society must have at least 300 members to secure a suitable revenue. The dues were reduced to these small amounts as a matter of experiment, in hopes that a membership of at least 300 could be secured. Thus far the experiment is a failure, and the question must at once be met, whether we shall attempt to increase the number of members, or shall return to a system of larger annual dues. Inasmuch as we have a fixed expense of $3 per member, as our cost of publishing the *Journal*, we have only $2.50 per member left to apply for other expenditures. To raise $750 for these, we require 300 members at the present dues. One hundred members at $10 would give $700, or about the same net result. At the beginning of the year fifteen "Topical Committees" were appointed, comprising some 40 different persons, and the following letter was sent to each member of every committee:

"*To the Members of Topical Committees:*

"The printed minutes of the 234th meeting, enclosed herewith, will inform you of your appointment as Members of these Committees. The welfare of the Society depends largely on the number and character of papers and topics presented for discussion, and it is your duty to furnish material on the particular subjects assigned to your respective committees. You have authority not only to obtain papers from members of the Society, but to present articles contributed by others whom you consider competent to instruct and interest the Society. The member first named on each Committee is its Chairman, and it is his duty to put himself in communication with its other members as soon as possible."

It was supposed that by placing the practical work of the Society, providing material for papers and discussions, in the hands of so many committees, the best results could be obtained in that direction. A reference to the proceedings of the Society does not show that any one of these committees has ever acted, except that one made a report on a subject especially referred to it. In October last I presented my resignation as Secretary, but as the Society has not yet filled the position I have continued to act to the present time, Dec. 6. From the date of our organization in 1869 I have continuously held this office, and I cannot now leave it without expressing my high appreciation of the uniform courtesy and kindness which have been shown to me by every member. For many years I have had a more intimate knowledge of the affairs of the Society than any other member, and have therefore, perhaps, felt a larger interest in it than any other one. In the future no one will rejoice more heartily in its prosperity than I, and I have faith to believe that both in the immediate future and in coming years, everyone of us may take worthy pride in the Western Society of Engineers.

L. P. MOREHOUSE, Secretary.

The financial statement was as follows:

Cash in hand, Jan. 1, 1887	$70.05
Cash paid for dues	760.00
Total	830.05
Disbursements	791.65
Cash in hand	38.40
Unpaid bills, $86.	

Verbal reports were received from the Chairman and Trustees. The committee on Nominations submitted the following resolution as an amendment to the by-laws:

"*Resolved*, That the annual dues be, and are hereby increased to the following amount; viz., resident members, $8.50 a year; non-resident members, $7.50 a year. Also that an initiation fee of $5 be paid by each person who hereafter becomes a member, and that such amount must accompany each application for membership, but will be returned if applicant be rejected."

W. S. BATES,
For Committee on Nominations, Etc.

After a brief discussion, in which the desirability of some change was generally conceded, the resolution was laid over under the rules.

A communication was received from J. A. L. WADDELL, calling the attention of the Society to his treatise on "General Specifications for Highway Bridges of Iron and Steel," and requesting that the society take some action in aid of the reforms which he is seeking to accomplish. The matter was referred to the regular Committee on Bridges to be hereafter appointed.

The following officers were elected:

President, A. GOTTLIEB; *First Vice-President*, JOHN W. WESTON; *Second Vice-President*, O. CHANUTE; *Secretary*, L. E. COOLEY; *Treasurer*, W. S. BATES; *Librarian*, G. A. M. LILJENCRANZ; *Trustee*, O. B. GREEN.

Mr. W. S. BATES, for the Committee on annual supper, reported that they had succeeded beyond expectations in carrying out the purposes of the committee, and that the subsequent proceedings must speak for themselves. On motion the meeting adjourned to the supper room.

The supper was partaken of by about 50 members, and was pronounced such a success that many of those present hoped that such events might be of more frequent occurrence. At its conclusion, DE WITT C. CREGIER, in behalf of the society, presented to L. P. MOREHOUSE, an edition of the Encyclopedia Brittanica. His remarks were felicitous, going back to the origin of the Society, and noting the fact that Mr. MOREHOUSE and himself were the only charter members present, and that Mr. MOREHOUSE had continuously held and discharged the duties of secretary since its formation 17 years ago. Mr. MOREHOUSE was entirely surprised at this testimonial and rose to the occasion in many happy remarks.

Speeches were made by the new President, A. GOTTLIEB, and by D. J. WHITTEMORE. Judge PENDELGAST spoke for the "Bench and Bar," which in this case pertained to the removal of rock benches and sand bars in the proposed waterway from Lake Michigan to the Mississippi river. L. E. COOLEY, *Secretary.*

Central R. P. I. Association.—There will be a reunion of former Students of Rensselaer Polytechnic Institute, at Kansas City, Mo., on Feb. 10, when it is purposed to effect a permanent organization, to be known as the Central R. P. I. Association, which will be composed of the former students of the Institute who reside in that portion of the United States which is included between the 87th and 107th Principal Meridians.

After organization there will be a banquet.

The committee appointed is: EDGAR B. RAY, 1883, J. A. L. WADDELL, 1875, FRANK W. TUTTLE, 1878, VIRGIL H. HEWES, 1881.

Indiana Society of Civil Engineers and Surveyors.—The 8th annual meeting was held at Indianapolis, Ind., Jan. 17, 18, and 19. The first day was devoted to routine business, discussion on questions of practice, etc. On the second day reports were submitted, questions discussed and the following papers read: "Drainage," by L. S. ALTER, of Kentland; "Topography," by Prof. PHILLIPS, of Purdue University; "Relation of Astronomy to Surveying," by Prof. C. A. HAEGRAVE, of the Central Normal College. L. BEEKMAN explained the features of his transits and Y level. On the third day reports were made, officers elected, committees appointed and a paper on "Construction of Roads and Bridges," read by M. S. FRIES, of Greenfield. The following officers were elected: Pres., J.C. PULSE, of Greenburg; Vice-Pres., E. B. VAWTER, of Lafayette; Recording Secretary, J. E. BROWN, of Frankfort; Corresponding Secretary, G. M. CHENEY, of Logansport; Treasurer, R. L. MORRISON, of Knightstown; Executive Committee, G. W. CHENEY, of Logansport; J. C. PULSE, of Greenburg; M. A. OSMER, of Logansport; R. H. WALLS, of Greencastle, and Prof. JACOB MORRIS, of Wabash College. The Society will meet at Indianapolis, Dec. 11, when the Tile Makers Association will be in session.

Liverpool Engineering Society.—The opening meeting of the present session of this society was held at the Royal Institution, Colquitt-street, on Wednesday, Jan. 11, CHARLES H. DAEBISHIRE, Assoc. M. Inst. C. E., president, in the chair. Upon taking the chair, the president delivered a short address to the meeting. A. W. BRIGHTMORE, M. Sc., then read a paper entitled "Some Recent Experiments on Iron and Steel and Riveted Joints." He reviewed the important series of experiments carried out at the instance of the Prussian Government by WÖHLER and BAUSCHINGER, and showed how these experiments pointed to the conclusion that, when the nature of the stresses in the members of any structure is subject to continual reversal, the maximum load consistent with the permanency of that structure is not more than one-third of what may with perfect safety be borne when the nature and amount of the stresses remain constant. He then considered the effect of different kinds of loading upon the elasticity of iron and steel. Proceeding to the consideration of riveted joints, he dwelt upon the principles that guide their design, and concluded by demonstrating the advantages of machine over hand riveted joints. The reading of the paper was followed by an animated discussion, which was prolonged to such an extent that it was finally resolved to further consider the matter at the next meeting.

Water-Works Reports.

Taunton, Mass.—The Water Commissioners have presented their report for the year ending Nov. 30, 1887, being the 12th annual report. The water supply has been satisfactory as to quality, but there is some anxiety as to the quantity available without drawing directly from the river. In July experiments were commenced for the purpose of ascertaining the probability of a supply from driven wells; the work was done by D. L. Barker, of Providence, R. I. The quantity of water does not seem to be sufficient, and the depth at which it is found is too great to make the

establishment of a separate pumping plant for driven wells economical. Details are given of the wells, tests, and the conclusions arrived at. The future source of supply will probably be the Middleboro ponds, but not for some years to come, and in the meantime it is thought a sufficient supply of ground water can be obtained from the valley of the Taunton river. During the year 1.71 miles of pipe were laid, bringing the total up to 54.62 miles, and 7,748 ft. of 8-in. were replaced with 16 in.; the service pipes were extended 1.56 miles, total 27.78 miles; there were also added 13 hydrants, total 470; 29 stop gates, total 347; 4 blow-offs, total 24, and 159 service taps. Of meters 110 were set, making a total of 782; 27 per cent. of the taps in use are metered. The pipe line under the river is to be replaced with a 20-in. main across the new bridge at Dean street.

The works were built by the city in 1876. The source of supply is ground water, with the Taunton river for emergencies; it is distributed by direct pumping. The pumping machinery was furnished by the Holly Mfg. Co., and the total pumpage for 1887 was 264,618,762 galls, pumped against an average dynamic head of 151.30 ft. The population is estimated at 23,674 for 1885; 21,400 on the line of pipe and 19,000 supplied. Of the 264,618,762 galls., 32,446,357 galls. passed through domestic meters and 68,672,071 galls. through manufacturers meters. Average daily consumption, 724,982 galls. The distribution pipes are of cast-iron, 4 to 20 ins., and 4,108 ft., less than 4-in. The ordinary range of pressure at the city square is 45 to 50 lbs. The services are of cement-lined, wrought-iron pipe, from ¾-in. to 1¼-in. diameter. The report contains tables of meters, pumping, water analysis, etc., plans of the Dean street river crossing and the driven wells, and a diagram of the tests of the wells. President, P. I. PERRIN; Superintendent, WM. R. BILLINGS.

Schenectady, N. Y.—The Water Commissioners have submitted their report for the year ending Nov. 1, 1887. A new 16-in main is recommended from the pumping station, to replace 600 ft. of 12-in main. Two new boilers and a No. 3 Gaskill engine have been put in by the Holly Manufacturing Co. The new intake and supply main were constructed under the supervision of the engineer, P. H. BAERMAN, no bids being received in answer to repeated advertisements; the supply pipe is 20 ins. diameter and has 13 ball joints in order to allow it to conform to the contour of the river bed. During the year 5,736 ft. of mains have been laid, including the setting of 6 double nozzle hydrants and 8 gates, at a cost of $4,240.42. There are now 16 miles 984 ft. of pipe, 154 hydrants and 88 gates. Attention is called to the increased waste; the total pumpage for the year was 542,651,137 galls., of which 137,000,000 galls. are estimated as waste. At this rate increased pumping capacity and larger mains will soon be needed; and to check this reckless waste a thorough system of inspection is recommended, and a general application of meters.

The works were built in 1871, by the Schenectady Water Co.; they were purchased by the city in November, 1885. The population is estimated at 20,000. The source of supply is the Mohawk river and the water is distributed by direct pumping. The pumping machinery consists of an engine by the Deane Steam Pump Co., and another by the Holly Manufacturing Co. The report contains a financial statement, pumping record, details of locations of mains, hydrants, etc., and the rules and regulations adopted. President, PETER VAN DYCK; Superintendent, M. O. CALDWELL.

CONSTRUCTION NEWS.

Water.

Water-Works.—*Massachusetts.*—Randolph. The new water-works for Randolph and Holbrook were tested by the water commissioners on Jan. 30. The hydrant pressure was 70 lbs., sufficient for fire purposes. The final test will be made shortly.—Milton. A water company is proposed to be organized, or rather two companies to supply different sections of the town, the supply to be obtained from Boston, Hyde Park or Quincy. Another scheme is for driven wells. The Water Committee adjourned the hearing indefinitely.

New York. Syracuse.—The Central City Water-Works Co., backed by J. F. MOFFETT, of Watertown, N. Y., is in favor of Skaneateles lake as a source of supply.—Westfield. It is proposed to dam the Little Chautauqua creek and obtain a reservoir at a higher elevation than by the proposed dam on the Big Chautauqua.

Maryland., Frederick.—The city proposes to issue bonds for $50,000 for increasing the water supply.—Catonsville. The Catonsville Water Co. will increase its capital stock.

Ohio.—Sidney. The city will abandon its gravity system of water supply and put in 2 compound, condensing engines of 2,000,000 galls. daily capacity each, to pump a supply from wells to a stand-pipe.—Cincinnati. A bill has been prepared to appoint a board of Water Supply Commissioners who are to investigate the condition of the water-works and examine plans for a new supply. They will report to the Board of Public Affairs.

Virginia.—Norfolk. The Seaboard Water Co. will be organized by W. B. Rogers, H. L. Smith and others; capital stock, $50,000.—Gordonsville. The town will issue bonds for water-works

Tennessee.—Morristown. A water company has been organized. Address W. A. JONES.

Georgia.—Rome. Water-works are to be built at East Rome.—Thomasville. A site for the new stand-pipe has been selected and work commenced on the foundations.—Carrollton. The mayor has appointed a committee to investigate the question of establishing a water supply.

Florida.—Gainesville. Water-works are projected. Address B. C. DRAKE.

Alabama.—Birmingham. Water-works are being built at Gate City by the Gate City Land Co.—Tuskaloosa. The Jeter & Boardman Water & Gas Association, of Macon, Ga., has commenced work on the water-works.

Illinois.—Havana. The water supply question is being agitated.—Morrisonville. Water-works are to be built.

Minnesota.—St. Cloud. The water company is laying a new intake pipe in the Mississippi river; it will run diagonally into the river from the pump house a distance of 800 ft.; the mouth will be protected by a stone crib and filter and there will be a second filter at the pump house.

Wisconsin.—New London. A gravity system of water-works is to be established.

Missouri.—Washington. Water-works will be established at an early date. An electric light plant will also be put in.

Mississippi.—Greenville.—The Greenville Water-Works Co. will begin work shortly and will put in an electric light plant. JAS. BURKE, General Manager.

Arkansas.—Rogers. Address Graham & Mason for particulars of the proposed water-works.

Nebraska.—Weeping Water. Owing to some mistakes in the recent vote on the issue of $15,000 bonds for water-works, another vote will have to be taken this month.—Lincoln. The Board of Public Works has been authorized to make such alterations in the contract with Mr. Burns for an additional water supply as will hasten the completion of the work.

Canada,—Belleville, Ont. The new water works built by Moffett, Hodgkins & Clarke, of Watertown, N. Y., were officially tested on Jan. 21, with satisfactory results.

Proposals Open.

Breakwater.—In St. Catherine's creek. OLIVER N. WILDS, Natchez, Miss. Feb. 6.

Artesian Well.—G. H. COLE, City Clerk, Toledo, O. Feb. 6.

Bridge, Piers, Etc.—Over Big creek. Howe truss bridge of 2 spans, 160 ft. and 80 ft.; 18 bents of trestling; 2 piers and 2 abutments of blue limestone laid in cement. Plans and specifications on file. THE BOARDS OF COUNTY COMMISSIONERS OF JENNINGS, SCOTT AND JEFFERSON COUNTIES, Auditor's Office, Vernon, Ind. Feb. 6.

Street Work and Sewers.—Street grading, culverts, etc.; cylindrical brick sewers, 24 in. inside diameter and 4 in. shell. Plans and specifications at the City Engineer's Office. G. H. COLE, City Clerk, Toledo, O. Feb. 6.

Water Pipe.—Cast iron pipe; 4-in., 12 tons of 2,000 lbs.; 6-in., 140 tons; 8-in., 20 tons; 12-in., 75 tons. H. C. CORTER, Superintendent of Water-Works, Toledo, O. Feb. 7.

Retaining Wall, Etc.—Building about 200 ft. of vertical wall and setting back the abutments of Beech street bridge at Syracuse. JAMES SHANAHAN, Superintendent of Public Works, Albany, N. Y. Feb. 8.

Broken Stone and Gravel.—Broken trap-rock stone, 7,800 cu. yds. of 2½ in.; broken Tompkins Cove blue stone, 5 200 cu. yds. of ¾-in.; Roa Hook gravel. THE PARKS COMMISSIONERS, 49, 51 Chambers street, New York City. Feb. 8.

Bridge.—Across the Saluda river. J. P. GOODWIN, Greenville, S. C. Feb. 11.

Street Improvement.—Plans and specifications at the City Engineer's office. G. H. COLE, City Clerk Toledo, O. Feb. 13.

Court House.—Extension of the court-house at Montreal. A. LEVEQUE, architect, 12 Place d'Armes. ERNEST GAGNON, Secretary, Department of Agriculture and Public Works, Quebec, Canada. Feb. 16.

Boilers.—Boiler power at Front street pumping station, equivalent to the evaporation of 36,000 lbs. of water per hour, and 15,000 lbs. per hour at the Hunt street station. A. G. MOORE, Engineer & Superintendent of Water-Works. THOS. G. SMITH, President, Board of Public Affairs, Cincinnati, O. Feb. 16.

Sewer.—Plans and specifications at the City Engineer's office. EUGENE SHINN, City Clerk, Dayton, O. Feb. 17.

Pumping Engine.—Capacity to pump 10,000,000 galls. per day from Eden reservoir into the Mt. Auburn service. High or moderate duty. Bidders to furnish plans and specifications. General specifications at the office of A. G. MOORE, Engineer and Superintendent of the Water Department. THOS. G. SMITH, President, Board of Public Affairs, Cincinnati, O. Feb. 23.

Bonds.—Artesian well and city hall bonds for $12,000; bonds, $1,000 each; 7% per annum; 20 years. H. C. HANSBROUGH, Mayor, Devils Lake, Ramsey county, Dak. March 5.

Contracting.

Stand-Pipe.—A stand-pipe is to be built at Franklin, Mass., in the spring.

Boylston Street Bridge.—The only bid for the Boylston St. bridge over the Boston & Albany R. R., received by JOHN W. MCDONALD, Superintendent of Streets, Boston, Mass., was from David H. Andrews, proprietor of the Boston Bridge Works, for $47,250. The contract was awarded to him on Feb. 1.

Armory.—The Armory Board opened bids, Jan. 30, for the building of the new Eighth Regiment armory, at Lexington avenue, 90th to 91st St., New York City. Of 30 bids presented, 3 were for the entire structure, 10 for the masonry alone, 3 for the carpentry, 3 for the iron work, and 8 for the plumbing. The lowest bid for the entire work was that of Isaac A. Hopper, of $284,490. The highest was by James H. Brady, $298,986. In separate bids the lowest for the entire work amounted to $286,160, and the highest to $337,960. The contract was awarded to Mr. Hopper.

Pumping Engines.—The following proposals for pumping engines, including foundations, connections, etc., were received Jan. 31., by the Water-Works Trustees, Sandusky, O.: CHAS. A. JUDSON, Superintendent: (the prices marked * include 2 boilers):

Bidder.	Class of Engine.	Size of Cylinders. H. P.	Size of Cylinders. L. P.	No. of Cylinders.	Size of Plunger.	Length of Stroke	Capacity in U. S. gals. per 24 hrs.	Duty 10 lbs Evaporation.	Steam Pressure.	Total cost of Plant.
		Ins.	Ins.		Ins.	Ins.				$
Knowles	Direct.	18	33¾	4	22¾	48	5,000,000	65,000 000	75	26,000,00
"	"	22	41	4	27	48	7,500,000	65,000,000	75	30,000,00
Worthington	"	21	36⅝	4	20	36	5,000,000	70,000,000	75	19,750,00
"	"	25	43⅞	4	24	36	7,500,000	70,000,000	"	22,750,00
"	"	21	42	4	20	36	5,000,000	105,000,000	"	29,500,00
"	"	25	50	4	24	36	7,500,000	105,000,000	"	31,750,00
"	"	18	36	4	21	25	5,000,000	105,000,000	100	25,500,00*
"	"	21	42	4	24	36	7,500,000	105,000,000	100	34,500,00*
Deane	"	22	40	4	26	48	7,500,000	65,000,000	75	34,000,00
"	"	22	40	4	26	36	7,500,000	"	"	30,000,00
"	"	28	52	4	26	48	"	"	"	41,000,00
"	"	28	52	4	26	36	"	"	"	39,000,00
"	"	18	34	4	21¼	48	5,000,000	"	"	26,400,00
"	"	18	34	4	21¼	36	"	"	"	24,000,00
"	"	24	44	4	21¾	48	"	"	"	31,700,00
"	"	24	44	4	21¾	36	"	"	"	29,000,00
Holly	Rotative	18	36	4	20	32	"	110,000,000	75	21,500,00
"	"	21	42	4	23½	36	7,500,000	"	75	28 000,00
"	Direct.	18	36	4	20	24	5,000,000	65,000,000	75	12,500,00
"	"	22	44	4	24	30	7,500,000	65,000,000	75	16,500,00

Boston & Lockport Block Co.—The manufacturing business formerly conducted by the Bagnall & Loud Block Co., of Boston, and the Penfield Block Co., of Lockport, N. Y., has been succeeded by the Boston & Lockport Block Co., with factories at Boston and Lockport, as formerly, and under former management. Both factories will brand their best goods with the "Star," their patent trade mark, and patrons may depend that former superior quality, sold under that brand, will be fully maintained by both factories in future. All future correspondence may be directed to either Boston or Lockport, as wants may require. Signed: Bagnall & Loud Block Co.; Penfield Block Co

Pipe and Specials.—The following proposals for cast-iron pipe and specials were received Jan. 27 by the Executive Board, Rochester, N. Y.; THOS. J. NEVILLE, Clerk:

MATERIAL.	Buffalo Cast-Iron Pipe Co. Buffalo, N. Y.		Donaldson Iron Co. Emaus, Pa.		R. D. Wood & Co. Phila., Pa.		McNeal Pipe & Foundry Co. Burlington, N. J.		Detroit Pipe & Foundry Co. Detroit, Minn.		Gloucester Iron Works. Phila., Pa.		Mellert Foundry & Machine Co. Reading, Pa.		Jackson & Woodin Man. Co Berwick, Pa.	
160 net tons of 12-in. straight pipe.	27.50	$1,400.00	28.00	$4,480.00	28.65	$4,584.00	29.50	$4,720.00	29.70	$4,752.00	29.96	$4,793.60	30	$4,800.00	31.10	$4,976.00
48 " 10-in. "	27.50	1,320.00	28.00	1,344.00	"	1,375.20	"	1,416.00	"	1,425.60	"	1,438.08	"	1,440.00	31.10	1,492.80
77 " 8-in. "	28.50	2,194.50	28.50	2,194.50	"	2,206.05	"	2,271.50	"	2,286.90	"	2,306.92	"	2,310.00	31.60	2,433.20
113 " 6-in. "	29.00	3,246.00	29.40	3,292.80	"	3,308.80	"	3,304.00	"	3,326.40	"	3,355.52	"	3,360.00	31.60	3,539.20
10 " 4-in. "	29.00	290.00	29.40	294.00	"	286.50	"	295.00	"	297.00	"	299.60	"	300.00	33.85	338.50
19,000 lbs. of special castings.	2½ c.	475.00	2½ c.	451.25	2.5 c.	546.25	2½ c.	498.75	2⅞ c.	437.00	2½ c.	498.75	2½ c.	522.50	2⅞ c.	532.00
Totals.....		$11,927.50		$12,056.55		$12,206.80		$12,503.25		$12,524.90		$12,692.47		$12,732.50		$13,311.70

Pumping Engines, Stand-Pipe, Etc.—At Sidney, O. an important change is to be made in the water supply. There will be two compound, condensing engines of 1,000 000 galls. daily capacity each, a stand-pipe, and wells for furnishing a water supply. Address WILBUR A. GINN, City Engineer.

Bridges.—The King Iron Bridge & Manufacturing Co., of Cleveland, O., has been awarded the contract for the iron work for 2 aqueduct bridges for the North Poudre Land & Canal Co., Larimer county, Col. They are both to be combination trusses of the Pratt type, one 80 ft. and one 60 ft. span.

Submerged Sewer Pipe.—At Brockville, Ont., the Sewer Commissioners have awarded the contract for pipe and flexible joints for the sewer outlet to Alex. Gartshore, Hamilton, Ont., at $35 per ton for pipe, and $40 each for flexible joints. The contract for laying the submerged sewer outlet, 950 ft. of 16-in. pipe, was awarded to J. F. Ward, of Jersey City, N. J., at $4.80 per lin. ft. The other bidders for this work were Logan & Dodbridge, of Brockville, $6.20 and M. H. Lefebvre, of Montreal, $6.45 per ft. WILLIS CHIPMAN is City Engineer.

The Volker & Felthousen Manufacturing Co., of Buffalo, N. Y., has contracted to erect a compound, condensing engine of 2,000,000 galls. capacity, for the Jamestown Water Supply Co., of Jamestown, N. Y.; also two condensing pumps of 1,500,000 galls. daily capacity each for the Pine Bluff, Ark., water-works. The company reports that the business for 1887 shows again of 300 per cent. over that for 1886, and that the works are kept running every night to 9 P.M.

Special Castings.—The following proposals for special castings for the Water Works Department were received by ANDREW RINKER, City Engineer, Minneapolis, Minn.: Harry McCarny, 2¼ cts. per lb. less 1%; Thos. Mullaly, 2¾ cts. less ⅛ of 1%; Lockwood, Upton & Co., 2½ cts. less ⅛ of 1%; North Star Oil Works, 2¾ cts. less ½ of 1%; Smith, Richardson & Co. 237 cts.; Crown Iron Works, 2.95 cts.; Menzel & Ferguson, 2¾ cts. All the bidders were Minneapolis parties. The contract was awarded to H. McCarny.

Water-Works Proposals.—*Herkimer, N. Y.*—The Water Commissioners will receive proposals till Feb. 18 for 4,647 gross tons (36,000 ft.) of 4 to 10-in., cast-iron pipe, 9 net tons of castings, 50 valves, 51 hydrants, 1 compound, duplex, non-condensing pumping engine with a capacity of 500,000 galls. per 10 hours, 1 horizontal tubular boiler; also stand-pipe 60 ft. diameter and 25 ft. high. The engineers are J. R. & F. K. BAXTER, 2 Bleecker street, Utica, N. Y.

Findlay, O.—The Water-Works Trustees will receive proposals till Feb. 15 for 2,650 net tons of 4 to 24-in. cast-iron pipe, 111,000 lbs. of castings, 107 stop valves, 139 hydrants, 107 cast-iron stop boxes; also 2 compound, duplex, non-condensing direct acting, pumping engines of 2,500,000 galls. daily capacity each, with boilers, etc. The consulting engineer is JOHN W. HILL, 21 Glenn Building, Cincinnati, O.

Artesian Wells.—The following were the bids received for the supply wells for the new water-works at Galveston, Tex.:

Louis Seigel, New York, 1,000 ft., without guarantee: 5 ins. minimum diameter, $5,000; 5½ ins., $5,500; 6 ins. $6,000; 7 ins., $7,000; 8 ins., $8,000. Extra depth, same proportionate price per foot for 1,500 feet or less.—J. L. Smith, Mexia, Tex.; without guarantee as to water: 5½ ins. diameter, $8.50 per lin. ft.; 7½ ins. $9; Extra depth same price to 1,500 ft.—J. W. Byrnes, Galveston, without guarantee of water: To reach 850 foot vein with 5-in. pipe, $7,500 each well; with 8-in pipe $8,500 each; with guarantee of 15,000 galls. per 24 hours $8,500; 25,000 galls., $8,750; 50,000 galls., $9,250; 75,000 galls., $9,500; 100,000 galls., $10,000; 150,000 galls., $12,000; 200,000 galls., $15,000.

All the bids were rejected and proposals will now be received till Feb. 15 for the boring of from 5 to 10 wells, to be 5, 6, 7, 8, 10, 12, 14, 16, 18, 20 or 24 ins. inside diameter, top measurement; proposals to state price per foot for each well for any depth up to 2,500 ft., the board reserving the right to stop at any point. Contractor to furnish proper-sized strainer with each well, if necessary; the tubing of said wells to be of standard pipe, the thickness and quality of which shall be specifically described in the proposal. Work to be commenced within 30 days from the letting of contract; proposal to state when said wells, respectively, are to be completed. Contractor to be paid for each well according to the diameter of the bottom or finishing pipe. See advertisement this week.)

Water-Works for Galveston, Tex.—The following is a list of bidders for the works, the contracts for which were given last week (p. 70): Works complete, except wells: McRae, Lally & Son, Detroit, Mich., $427,145; J. W. Byrnes & Co., Galveston, $476,808.67; Moffett, Hodgkins & Clarke, Watertown, N. Y., $435,000; Denison & Cowell, Muscatine, Ia., except stand pipe, storage tank and wells, $348,000, or $331,800 with only 2 ft. cover over pipes: Ricker, Lee & Co., Galveston.—Pumping engines; Deane Steam Pump Co., Holyoke, Mass.; Geo. F. Blake Mfg. Co., New York City; Henry R. Worthington, New York City; Knowles Steam Pump Co., New York City; Gordon & Maxwell, Hamilton, O.; Jackson Foundry & Machine Co., Jackson, Mich.; Holly Manufacturing Co., Lockport, N. Y.—Boilers; Union Iron Works Co., Chattanooga, Tenn.; St. Louis Boiler Yard & Sheet Iron Works.—Pipe and specials: Mellert Foundry & Machine Co., Reading, Pa.; R. D. Wood & Co., Philadelphia, Pa.; McNeal Pipe & Foundry Co., Burlington, N. J.; Gloucester Iron Works, Philadelphia, Pa.; Shickle, Harrison & Howard Iron Co., St. Louis, Mo.; Walker, Fowler & McVitie, Galveston; Warren Foundry & Machine Co., New York City; National Tube Works Co., Chicago, Ill.—Pipe laying; John Maxwell, St. Louis; Franklin A. Snow, Providence, R. I.; R. C. Storrie, Fort Worth; Richard Dixon, Sault Ste. Marie, Mich.; John J. Everson, Akron, O.; Fruin-Bambrick Construction Co., St. Louis; C. E. Gray, Jr., Chicago; John O'Donnell & Bro., St. Louis; Carothers & Hutzel, Newport, Ky.; M. Philbin & Co., Grand Crossing, Chicago; Denison & Cowell, Muscatine, Ia.; J. R. Gillett, Norfolk, Va.; Thomas & Gorman, Houston, Tex.; T. C. Brooks & Co., Jackson, Mich.; H. Merigold & Co., Lima, O.; A. W. Stevens, Logansport, Ind.; J. B. Bostwick, Galveston; Snyder & Williams, Dayton, O.; Wm. Paxton, St. Louis.

Valves and hydrants: W. S. Payne & Co., Fostoria, O.; Daniel Kennedy, New York City; R. D. Wood & Co., Philadelphia, Pa.; Ludlow Valve Mfg. Co., Troy, N. Y.; Chapman Valve Mfg. Co., Indian Orchard, Mass.; Eddy Valve Co., Waterford, N. Y.; Holyoke Hydrant & Iron Works, New York; Louis Schwartz, New Orleans; Holly Mfg. Co., Lockport, N. Y.; Galvin Brass & Iron Works, Detroit, Mich.; Bingham & Taylor, Buffalo, N. Y.; Gloucester Iron Works, Gloucester, N. J.; Jonson F'dry. & Mach. Co., New York; Mellert Foundry & Machine Co., Reading, Pa.—Stand-pipe and storage tanks: Jackson Foundry & Machine Co., Jackson, Mich.; L. B. Stevens, Toledo, O., Union Iron Works Co., Chattanooga, Tenn.; Shickle, Harrison & Howard Iron Co., St. Louis, Mo.; Thomas & Gorman, Houston, Tex.; Tippett & Wood, Phillipsburg, N. J.; J. B. Bostwick, Galveston.—Buildings and chimney; L. B. Stevens, Toledo, O.; Harry Devlin, Galveston.—Supply wells; all bids rejected, prices given elsewhere.

The long list of bidders, and the various parts of the country from which bids have been received for the water-works at Galveston and Dallas, show the value of judicious advertising in a technical paper. Advertisements for proposals for both these works were published in ENGINEERING NEWS, the first 6 times and the latter twice, and the large range of the bids is undoubtedly due to these advertisements, for ENGINEERING NEWS goes to all the largest and best contractors and manufacturers of supplies throughout the country. It is therefore the best medium for advertising for proposals for work of all kinds, and is the best paper that contractors and manufacturers can have to tell them what is wanted and what is being done. "A word to the wise."

Water-Works for Dallas, Tex.—The Water Commissioners have awarded the contract for pumping engine to the Holly Manufacturing Co., of Lockport, N. Y., at $20,000. The contract for excavating reservoirs, river work, conduit and pump well was awarded to McRae, Lally & Son, of Detroit, Mich., at $85,000; the prices are as follows: Excavation per cu. yd. 32 cts., concrete per cu. yd. $5, apron stone per cu. yd. $10, apron curb per lin. ft. $1, stone lining per sq. yd. 60 cts., brick masonry in walls per 1000 brick $16, brick masonry in collars and piers per 1000 brick $14, cement lining in bottoms of reservoirs 45 cts. per sq. yd. Vitrified pipe furnished and laid per lin. ft.: 2-in. 16¼ cts., 3-in 19 cts., 4 in. 19½ cts', 6-in. 24½ cts., 8-in. 29¾ cts., 10-in. 39½ cts., 12-in. 47 cts., 14-in. 54½ cts., 15-in. 59⅛ cts.; Y's 6x6 each 67 cts., 8x8 each 90 cts, 10x8 each $1.30, 12x8 each $1.75, $2, 15x8 each $2.25; 8-in. ¼ curves each 85 cts.; vitrified pipe, 4-in. diameter, with hand holes, per lin. ft. 27 cts., 6-in. 37 cts., 8-in. 47 cts., 10-in. 67 cts., 12-in. 82 cts., 14-in. 87 cts., increases 2 to 3-in. each 32 cts., 3 to 4-in. 40 cts., 4 to 6-in. 55 cts., 6 to 8-in. 70 cts., 8 to 10-in. $1, 10 to 12-in. $1.25, 12 to 14-in. $1.45, 14 to 15-in. $1.60, 8 to 16-in. $1.95, 8 to 20-in. $2.70; brick sewer per lin. ft. $6; cast-iron pipe laying per ft. 16-in. 50 cts., 20-in. 90 cts., 24-in. $1.40, 30-in. $2, cast-iron pipe $40 per ton, special castings $65 per ton; laying cast-iron pipe, 36-in., $2 per lin. ft., 48-in. $2.75; valves, 24 in. $150, 20-in. $100, 16-in. $75. A list of bids was given on p.p. 52,53. W. E. PARRY is City Secretary.

RAILROADS

East of Chicago.

Existing Roads

Columbus & Eastern.—At the recent annual meeting, the controlling interest was found to be in the hands of the Cleveland & Canton syndicate, and President H. A. BLOOD and his friends were chosen as officers of the company. The Cleveland & Canton has just placed its issue of $2,000,000 bonds with Coffin & Stanton, of New York, and the Montreal Investment Co. of Chicago. The funds will be principally used in changing the line to standard gauge, building the new Cleveland depot, and purchasing new equipment.

Waterbury & Meriden.—The first trip over this new Connecticut road was made Jan. 27. The line is 17 miles in length.

McKeesport & Bellevernon.—About 100 men are now at work on this Pennsylvania road under contractors Drake & Stratton, of Fittsburg. A line in the same interest is also under construction from Monongahela City to Finleyville.

Lehigh Valley.—Opinion is divided as to whether the company really intends to build the line which it has surveyed from Geneva to Buffalo, or is only working a game of bluff for obtaining a favorable trackage contract from the Erie or West Shore.

Pennsylvania.—A survey is in progress for a branch line from Latrobe, Pa., to the Hostetter Coke Company's fields, about five miles.

Ohio & Northwestern.—A force is at work on the trestles and bridges of the Hillsboro branch and it will be changed to standard gauge early in the spring. The Georgetown branch will be extended this season to Ripley.

New Projects and Surveys.

Delphos & Paulding.—

DELPHOS, O., Jan. 26, 1888.

EDITOR ENGINEERING NEWS:
This line has been located from Delphos to Paulding, about 20 miles. Since the survey was completed, some months ago, the company has taken no further steps towards building the line. It is likely that a new organization will take up the matter and put the road through the coming summer. Dr. C. A. EVANS is President. C. W. RISLEY, *Secretary.*

New York & Long Island.—This company has applied to the Brooklyn City council for permission to build a double track freight railroad through the streets of the city from the terminus of its proposed tunnel beneath the East river; the line to be used only between the hours of 12 midnight and 5 A. M.

Buffalo & Williamsville.—A new company has been organized at Buffalo, N. Y., to build the line from Buffalo to Williamsville. CHAS. O. POOLE, LEONARD DODGE, and others of Buffalo are interested.

Wharton Valley.—A railroad is projected from New Berlin on the New York, Ontario & Western R. R. to Edmeston, N. Y. CALEB CLARK, President of the First National Bank of Edmeston is interested.

SOUTHERN.

Existing Roads.

Charleston, Cincinnati & Chicago.—An engineer who has recently been examining the route of this line, writes us that the road is in operation from Black's, S. C., to Rutherfordton, N. C., 45 miles. From Camden, S. C., north, track has been laid for 21 miles and will be completed to Black's by April 30. The line is practically located from Rutherfordton to White House, 58½

miles south of Ashland, Ky. Besides the projected line to Augusta, a branch will be built from Lancaster, S. C., north to Charlotte, N. C.

Covington & Macon.—According to all reports, this company has before it a season of brighter prosperity than it has yet known. Alexander Brown & Sons of Baltimore, have agreed to market the bonds of the road and supply it with the necessary funds to build the extension from Monticello to Athens at once. Branches to Eatonton, Griffin and Atlanta are also on the programme. Col. E. C. MACHEN, 55 Broadway, New York City, has the general charge of construction. The offices of the company are at Macon, Ga.

Alabama Great Southern.—Considerable work is to be done on the division between Birmingham and Chattanooga in the way of ballasting and laying new steel rails.

Cincinnati, Selma & Mobile.—It is proposed to extend this road from its present western terminus at Akron, Ala., to a connection with the Kansas City, Memphis & Birmingham R. R. FRED. WOLFFE of New York, is President, and CECIL GABBETT, Montgomery, Ala., is General Manager.

Tennessee Midland.—At the annual meeting of this company, it was stated that the division now nearly completed from Memphis, to Jackson, Tenn., will be opened for business in the early spring.

Chesapeake & Ohio.—A project is on foot to build a line from Paducah, Ky., to Cairo, and a charter will be asked from the legislature.

West Virginia Central & Pittsburg.—At the annual meeting in Baltimore the old officers were re-elected. The extension now building runs from Thomas to the Cheat river, 13 miles. The directors were authorized to extend the road from Thomas toward Leadsville, Randolph County, W. Va., a distance of 32 miles. The president was authorized to purchase the additional rolling stock needed by the company.

Louisville Southern.—About 10 miles of track has been laid from Louisville to Jeffersontown, and the remainder of the line is nearly ready for the track. It is expected that the tracklaying will be pushed through as soon as the weather permits.

East & West Alabama.—The holders of the bonds of this company, which was bankrupted at the failure of the New York banking house of Grovesteen & Pell, are taking steps to reorganize the company and extend the line.

Georgia Pacific.—Chief Engineer MOTLEY is making estimates for the projected extension across the State of Mississippi to submit to the directors. The matter will probably be decided upon at this month's meeting of the board.

Georgia Southern & Florida.—The Chief Engineer of this road is Mr. WM. H. WELLS, of Macon, Ga., not Mr. W. S. GREENE as given in our list of officers of new Southern railroads in our issue of Jan. 14.

New Projects and Surveys.

Wilmington Sea Coast.—This 10 mile road from Wilmington, N. C., to Wrightsville, is to be built by W. H. & J. H. Chadbourn, the same firm that built the Wilmington, Chadbourn & Conwayboro road. WILLIAM LATIMER is President, and J. H. CHADBOURN, General Manager.

Johnson City Belt.—This company has been formed to build a railroad about Johnson City, Tenn. F. A. STRATTON is President, and J. E. CRANDALL, Treasurer.

Memphis, Oxford & Columbus.—It is reported that the contract for building this road from Memphis, Tenn., to Columbus, Miss., has been let to Crumpton & Co., of Chicago. F. N. ABBOTT, of Abbott, Miss., is given as the President. We do not vouch for the truth of the above item in any respect, as it reads very much like a hoax.

Winterville & Pleasant Hill.—

WINTERVILLE, Ga., Jan. 24, 1888.

EDITOR ENGINEERING NEWS:

This railroad will run from Pleasant Hill, Ga., *via* South Winterville, to a connection with the Georgia R. R., a distance of 9½ miles. Surveys will begin Jan. 30. Right of way has been secured and contracts let.

JAMES M. SMITH, *President*.

THE NORTHWEST.

Existing Roads.

Winnipeg & Hudson Bay.—The suit of Mann & Holt, the contractors who built the completed portion of this line to obtain possession of the road, has been defeated. President HUGH SUTHERLAND is jubilant over his victory, and thinks that a large amount of work will be done on the line during the coming season.

Illinois Central.—It is stated that the company intends to begin work early in the spring on a line to St. Louis to run either from Champaign, Tuscola, or Mattoon. — That ever hopeful Dakota journal, the Bismarck *Tribune*, says that a well known citizen has had a letter from a friend who is a book keeper for a contractor who has a contract for grading about 50 miles of road for the Illinois Central on the line from Sioux Falls to Bismarck. This well known citizen's correspondent's employer intends to begin work "as soon as the frost is out of the ground."

Chicago & Eastern Illinois.—It is rumored that this company will build the line, noted on our last weeks map as surveyed from Tuscola to Shelbyville, through to St. Louis.

Chicago, Milwaukee & St. Paul.—A very interesting but not very creditable rumor is in circulation announcing that this company is negotiating for control of the Chicago & Eastern Illinois and Chicago & Indiana Coal roads for the purpose of obtaining access to the coal fields of Illinois and Indiana and carrying coal to all points on its system direct from the mines.

Indianapolis, Decatur & Western.—The Decatur & Western has been incorporated by officers of this company to build a railroad from Decatur to Beardstown. This is the extension of the old "I. D. & S." noted upon our last week's map.

Northern Pacific.—Besides the surveys noted upon our last week's map it is reported that this company will build branches north to tap the new line of the Manitoba at Fort Buford and Great Falls.

Missouri Pacific.—The Nebraska Southern company has been incorporated in this interest to build from Nuckolls Co. to the west line of the State.

New Projects and Surveys.

Duluth, Northwestern & Winnipeg.—This company has been organized at Duluth to build a railroad through the same country, which the old Duluth & Winnipeg scheme was projected to open up. A surveying party is to be sent out this month to run a line from Cloquet to Grand Rapids and thence to a point near Fargo. The following are the incorporators of the enterprise: R. S. MUNGER, J. D. ENSIGN, D. A. DUNCAN, H. H. BELL and L. MENDENHALL, of Duluth; C. N. NELSON, of the C. N. Nelson Lumber Co.; J. B. HOLMES, President of the Duluth & Manitoba road, and C. W. WELLS, of the Wells-Stone Mercantile Co. R. S. MUNGER is President, and J. B. HOLMES, Vice President.

Omaha, Lincoln & Southwestern.—As noted more fully in our correspondence column, Mr. F. de FUNIAK, of Louisville, Ky., is *not* the Chief Engineer of this proposed road as stated in the letter from President L. S. JONES in our issue of Jan. 21.

THE SOUTHWEST.

Existing Roads.

San Antonio & Aransas Pass.—Reports that the Santa Fé is still negotiating for a controlling interest in this company continue to circulate. The company has now about 400 miles in operation, and its latest project is a line eastward through Louisiana to the Mississippi river.

Missouri, Kansas & Texas.—Rumors that this company is to be placed in a receiver's hands are in circulation in financial circles, the purpose being to force the bond holders to consent to a scaling down of their securities. It is stated that some of the phlegmatic Amsterdam bond holders of this company do not propose to submit tamely to this sort of treatment, and have formed an association to protect their interests.

Chicago, St. Paul & Kansas City.—The extension from St. Joseph, Mo., to Kansas City is to be pushed through at once. The company has made a traffic contract with the Kansas City Wyandotte & Northwestern for the use of their tracks from Leavenworth to Kansas City and grading on the line from St. Joseph to Leavenworth will be pushed at once.

Central Missouri.—A surveying party is at work on the final location of this road *via* Columbia, Rocheport and Fayette.

St. Louis & San Francisco.—The Kansas Midland extension has just been opened for business. The company has just marketed an issue of $7,144,000 bonds to retire the same amount of South Pacific bonds which mature in July.

Kansas City, Fort Scott & Gulf.—The company will probably build a bridge across the Mississippi river at Memphis at an early date, if government aid can be secured.

New Projects and Surveys.

Kansas, Texas & Mexican.—This company has filed its charter in Kansas, by which instrument its capital stock is set at $50,000,000 and its proposed line is to run from Kansas City, Kan., to El Paso, Tex., 1,200 miles, with branches to Albuquerque, N. M., Falls City, Neb., Leavenworth, Kan., and various other points. J. D. BOWERSOCK, Mayor of Lawrence, Kan., is one of the incorporators.

Dallas & New Orleans.—Incorporated in Texas, by MORGAN JONES of Fort Worth, G. P. MOROSINI, of New York City, T. J. OLIVER of Dallas, and others, to build a railroad from Fort Worth to the Louisiana State line.

Kansas City & Sabine Pass.—The surveyors at work on this road have reached Fort Smith, Ark. It is stated that the contracts have been let for the line from Kansas City to Pierce City, Mo.

Handley, Edenville & Hirsch Lake.—A company has been organized at Handley, Tex., to build a railroad 5½ miles in length. C. A. JENNINGS is President, and W. A. DIEDBOUGH, General Manager.

Leavenworth & Denver Air Line.—The preliminary survey of this Kansas road has been completed from the Blue river to the Colorado State line, and the engineers are now at work on the line from Leavenworth, west. JOHN MCCARTY is Chief Engineer.

New Orleans, Natchez & Fort Scott.—A Chicago syndicate is considering the matter of furnishing funds for this proposed road and has had an examination of the proposed route made by an engineer, Mr. L. D. LATHAM. It is understood that his report will be a favorable one.

ROCKY MOUNTAIN & PACIFIC.

Existing Roads.

Chicago, Rock Island & Pacific.—The citizens of Denver, Col., are very anxious that the importance of their city as a railroad center should not be forgotten. They recently sent a delegation to Chicago to explain to President CABLE the fact that Denver is the commercial center of the whole Rocky Mountain region and requesting him to announce that point as the western terminus of the Chicago, Kansas & Nebraska extension. Mr. CABLE stated that the plans of the company were not yet decided upon, but that at the proper time the company would do whatever it considered best for its own interests.

Northern Pacific.—The Missoula & Bitter Root Valley road in Montana has been completed for a distance of 40 miles from Missoula and is being operated by the construction department.——A branch of the Cascade division has been incorporated as the Cle-elum.

Seattle, Lake Shore & Eastern.—The 45 miles of this Washington Territory road from Seattle to Squak Mines have been completed. It is stated that capital has been secured for the contemplated extension to Lewiston, Idaho, which will be pushed through the coming season. F. H. WHITWORTH, Seattle, W. T., is Chief Engineer.

Montana Central.—President J. J. HILL of the Manitoba calls for proposals for $2,000,000 first mortgage 6 per cent. bonds on this line guaranteed by the St. Paul Minneapolis & Manitoba company. The Montana Central is authorized to build a total of 212 miles, of which the line from Great Falls to Helena, 97 miles, is completed and in operation, and the branches to Rimini, Marysville and Sand Coulee are graded and ready for tracklaying, which will be done as soon as weather permits. The line to Butte is delayed by the long tunnel 3,500 feet of which remain to be driven. It is expected that the line will be open for business, however, by September or October.

San Francisco & San Joaquin Valley.—This company which has been doing considerable grading near Fresno, Col., is reported as likely to stop work on account of lack of funds. This is the road which has been stated to be backed by the Santa Fé company for a line to San Francisco. J. R. WILBUR of San Francisco is President.

Chicago & Northwestern.—It is reported that a 100-mile contract has been let on the Wyoming Central Ry., from Glen Rock west. The report needs confirmation.

New Projects and Surveys.

Stockton & Bakersfield.—One FRANK AUSTIN of Stockton, Cal., recently started a railroad boom in the San Joaquin valley, by stating that a certain company proposed to build at once a road from Stockton southeast to Bakersfield, Cal., to parallel the Southern Pacific, and wanted several hundred thousand dollars worth of stock subscriptions from the towns along the route. He has also done some work negotiating for real estate for "terminals" near San Francisco, and now states that he represents no less a corporation than the Chicago, Milwaukee & St. Paul. It is news indeed if this corporation is drumming up local aid for a line in California distant some 1,400 miles air line from its terminus farthest west at Kansas City. Should this be true, we should like to inquire whether they propose to build a connection with their new line "this season." But if Mr. AUSTIN has no authority from the company to work up subsidies, it may be asked why the managers do not take pains to expose his pretentions. But then why should they? The cities which Mr. AUSTIN has "worked" are pleased with the idea of a new railroad, the newspaper press grows voluble over the wonderful extent of railway enterprise nowadays, and like the good natured fellows in the story, the St. Paul managers may say "it amuses them and don't hurt us."

Rio Grande & Utah.—The projectors of the railroad line from Algodones, N. M., *via* Durango, Col., to Salt Lake City, have incorporated under the above name, and announce themselves as an independent corporation with only the "moral support" of the Santa Fé. The principal place of business is to be at Santa Fé, and the line to Durango, about 200 miles, is to be completed this year. The following are the company's directors: J. W. CONLEY of Chicago; WILLIAM R. MERRIMAN and E. C. LONG of St Paul, Minn.; F. W. CARPENTER of Providence, R. I.; C. S. CLAPP of Binghampton, N. Y.; HENRY L. WALDO of Santa Fé; BENJAMIN L. JONES of Albuquerque, and BENJAMIN L. COOK of Chicago.